MARYLAND
GEOLOGICAL
SURVEY

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LETTER OF TRANSMITTAL

To His Excellency ALBERT C. RITCHIE,

Governor of Maryland and President of the Geological Survey Commission.

Sir:—I have the honor to present herewith the eighth of the series of reports dealing with the systematic geology and paleontology of Maryland. These volumes represent the technical scientific presentation of the facts on which are based the conclusions dealing with the mineral deposits in the formations under discussion. The preceding reports of this series have dealt with the Cambrian and Ordovician, Devonian, Lower Cretaceous, Upper Cretaceous, Eocene, Miocene, and Plio-Pleistocene deposits and the remains of animal and plant life which characterize them. The present volume treats of the Silurian deposits of western Maryland. I am,

Very respectfully,

EDWARD BENNETT MATHEWS,

State Geologist.

THE JOHNS HOPKINS UNIVERSITY,
BALTIMORE, *December*, 1922.

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PREFACE

The present volume is the eighth of a series of reports dealing with the systematic geology and paleontology of Maryland. The reports thus far issued include the Cambrian-Ordovician, Devonian, Lower Cretaceous, Upper Cretaceous, Eocene, Miocene, and Pliocene-Pleistocene. Reports on the Crystallines, Carboniferous, and Triassic are not yet issued but are now in varying stages of completion.

The present volume is devoted to a careful description of the Silurian deposits and their contained fauna. The Silurian rocks are limited to western Maryland where they occur in a series of synclines where the folding of the strata brings the different units to the surface. The strata consist of a thick series of limestones, sandstones, and shales and represent the geological formations in which valuable deposits of iron ore have been found over a wide area of the Appalachians from New York to Alabama. Unfortunately these deposits in Maryland are too lean in metallic content to make their exploitation commercially profitable. The Silurian deposits have also been the source of pure quartz sands for glass making and also limestone for the supply of hydraulic cement. The shales of these strata have not been exploited for brick, tile, or other ceramic products but particular local areas favorable for such purposes may ultimately be developed.

The volume represents the combined work of a number of individuals, specialists in their respective fields of research, who have been assisted in their field work by graduate students from The Johns Hopkins University. Most of this work has been conducted under the leadership of Dr. Charles K. Swartz who has contributed the general chapters on the Geographic Distribution, the Stratigraphy, and Paleontological Relations of the Silurian section. Dr. Swartz has also furnished the systematic accounts of part of the invertebrate fauna with the collaboration of Dr. W. F. Prouty, now Professor of Geology in the University of North

Carolina, whose dissertation submitted to The Johns Hopkins University is incorporated in this volume.

The report on the Maryland Silurian formations by Dr. E. O. Ulrich and Dr. R. S. Bassler and their paper on the Paleozoic Ostracoda with their stratigraphic interpretation of these interesting organisms which are so prominent an element in the Silurian formations of Maryland, represent a marked contribution to existing knowledge and constitute an important part of the present volume.

The Maryland Geological Survey has been greatly benefited by co-operation with the U. S. Geological Survey and is especially indebted to the Director of the latter organization for permission to publish the result of Dr. Ulrich's life-long studies of the Ostracoda and Silurian stratigraphy. The State Survey is similarly indebted to the Secretary of the Smithsonian Institution for permission to publish the results of Dr. R. S. Bassler's studies on the Bryozoa and of the Ostracoda in collaboration with Dr. Ulrich.

It is felt that the publication of this volume represents a distinct contribution to the advance of science by Maryland which will redound to the credit and benefit of the State.

GEOLOGIC RELATIONS AND GEOGRAPHIC DISTRIBUTION OF THE SILURIAN STRATA OF MARYLAND

BY

CHARLES K. SWARTZ

Geologic Relations.

The State of Maryland is divisible into three parts which differ strikingly in their geology and in their topographic features. These divisions are known as the Coastal Plain, the Piedmont Plateau, and the Appalachian Province. The Coastal Plain, forming the eastern part of the State, extends from the present margin of the continental shelf to a line passing through the cities of Baltimore and Washington. Its subaerial portion is a flat, almost featureless plain lying near the level of the sea. It is underlain for the most part by unconsolidated clays, sands, and gravels of Mesozoic and Cenozoic age which dip at a low angle toward the southeast.

The Piedmont Plateau forms the central part of the State, extending from the Coastal Plain to the east side of the South Mountain. It is an undulating plateau, more rugged than the Coastal Plain and attains a maximum elevation of 1000 feet. It is formed of ancient, intricately-folded and greatly faulted strata, all of which have been rendered metamorphic by intense crushing and extensive igneous intrusions. Subsequent to their formation they were eroded to a plain which was later elevated and dissected by erosion to form the present land surface.

The third division, the Appalachian Province of Maryland, extends from South Mountain to the western limits of the States, being a segment of the more extended Appalachian Province of eastern North America.

The Appalachian Province is divided into three districts, known as the Blue Ridge district, the Greater Appalachian Valley, composed of the

Great Valley and the Alleghany Ridges, and the Alleghany Plateau. Each district presents certain marked physiographic characteristics that separate it from the adjacent areas on the east and west.

The Blue Ridge district consists of the Catoctin and Blue Ridge mountains uniting to form the greater highland of South Mountain in the southern part of Pennsylvania. Beginning with an elevation of 2000 feet at the Maryland line, this highland gradually declines southward to the Potomac River where it has an elevation of less than 1500 feet at Maryland Heights overlooking the Potomac Valley. The eastern border of this district is formed by the Catoctin Mountain, which extends as an almost unbroken highland from the Pennsylvania line to the Potomac River at Point of Rocks. Succeeding the Catoctin upon the west is the Middletown Valley, which drains southward into the Potomac River through the Catoctin Creek. Along the western side of this district is the Blue Ridge Mountain proper. It extends as a sharply defined range from the South Mountain of Pennsylvania to the Potomac River, which it reaches at Weverton. Its crests form the boundary line between Frederick and Washington counties. The Blue Ridge in Virginia is not the direct continuation of the mountains so named in Maryland, but of a smaller range, the Elk Ridge, which adjoins the Blue Ridge on the west and reaches the Potomac River at Maryland Heights opposite Harpers Ferry.

The Greater Appalachian Valley embraces all of the country lying between the Blue Ridge on the east and Dans Mountain or Alleghany Front on the west. It admits of a twofold division into the Great Valley on the east and the zone of Alleghany ridges on the west. The Great Valley, known as the Hagerstown Valley in Maryland, the Cumberland Valley in Pennsylvania, and the Shenandoah Valley in Virginia, is a broad lowland, the floor of which averages from 500 to 600 feet in elevation, gradually increasing in height from the Potomac Valley toward the Pennsylvania line. It extends from the Blue Ridge on the east to North Mountain on the west. It is drained by the Antietam River on the eastern side and the Conococheague River on the western side, both of these streams having their sources in Pennsylvania and flowing southward to the Potomac River. The Alleghany ridges which extend from North Mountain to the Alleghany Front consist of a series of parallel ridges of varying elevations that extend from north to south across the state. Among the more important are North Mountain, Tonoloway Ridge, Sideling Hill, Town Hill, Green Ridge, Warrior Mountain, Collier Mountain, Martin Mountain, Nicholas Mountain, Shriver Ridge, and Wills Mountain. Between them are valleys that are drained mainly to the southward into the Potomac River. They vary in character, some being narrow and deeply trenched, while in others broad, level-topped areas appear, the origin of which will be shortly discussed.

The Alleghany Plateau forms the western part of the Appalachian Region and extends from the Alleghany Front to the western limits of the state. This highland, like the districts which lie to the eastward, is continued far beyond the confines of the state. To the southward it can be traced through Virginia, Kentucky, and Tennessee to northern Alabama, where it is known under the name of the Cumberland Plateau. In Maryland this district consists of a broad highland across which ranges of mountains extend from northeast to southwest, reaching elevations of 3000 feet and more at several points in Big Savage, Great Backbone, and Negro mountains. The leading ranges of the district are Dans Mountain, Big Savage Mountain, Great Backbone Mountain, Negro Mountain, Winding Ridge, and Laurel Hill. The streams flow in part to the southward or eastward, as the case may be, into the Potomac River, and in part to the northward through the Youghiogheny Valley into the Monongahela River whence the waters reach the sea through the Ohio and the Mississippi. The latter district comprises much the larger part of Garrett County.

The strata of the Appalachian Province were all folded into lofty mountains near the end of the Paleozoic era, the center of the most intense folding being in the east. The entire area was then reduced by erosion to an approximate plain which was subsequently elevated by successive uplifts to its present altitude. The existing mountains were carved out of this elevated plain by the action of rain and running streams which eroded the softer and more soluble rocks to form the floors of the valleys while the harder and less easily eroded strata form the intervening flat-topped ridges upon whose crests are still preserved traces of the original plain. The erosion was most active where the rocks were most highly folded, hence rugged mountains and deep valleys were carved out of the more highly folded eastern strata while the much less folded and less eroded western beds constitute the elevated Alleghany Plateau.

GEOGRAPHIC DISTRIBUTION

The Silurian strata of Maryland are exposed at various places in the highly folded mountainous part of the state described above as the Greater Appalachian Valley, the area in which they are found being bounded on the east by North Mountain and on the west by the Alleghany Front.

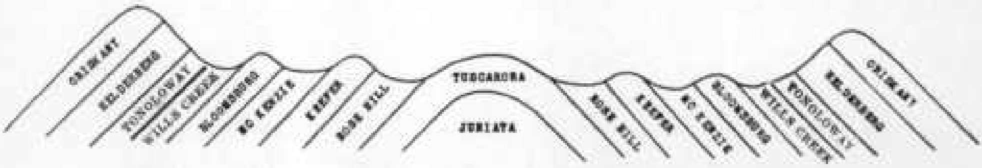
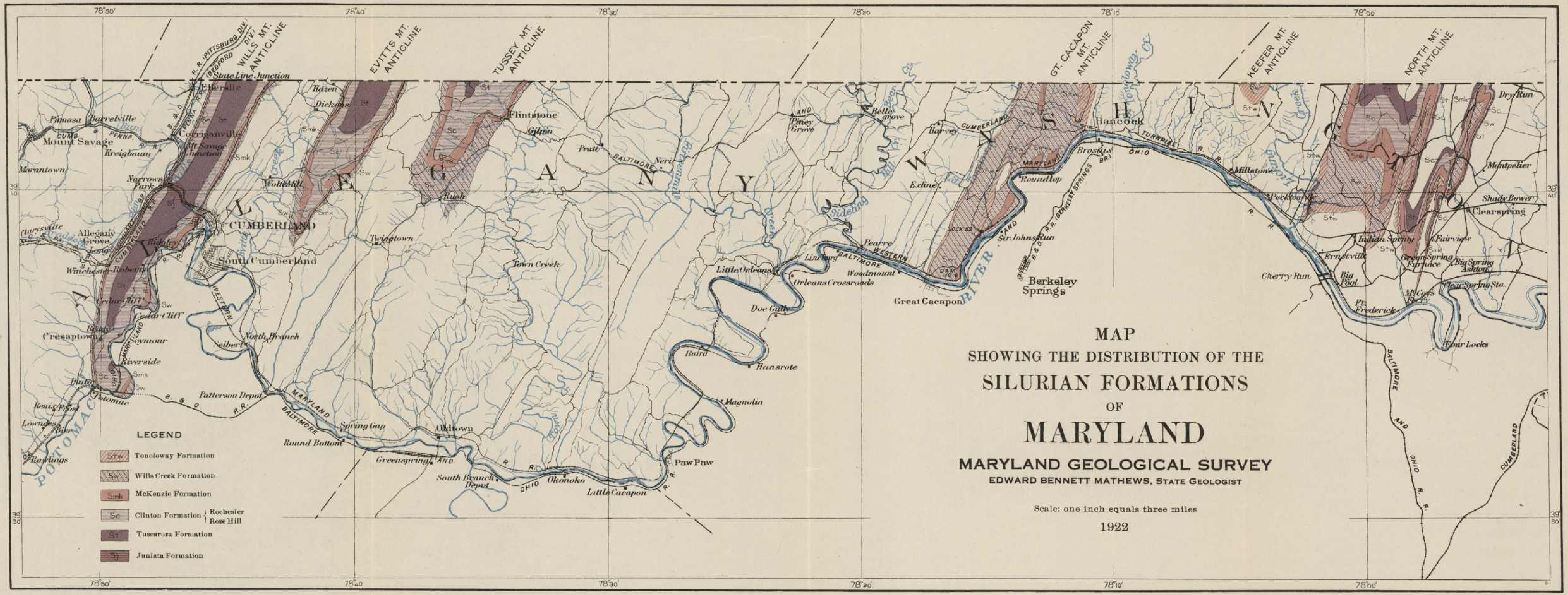


FIG. 1.—Section Showing Structure and Topography Across Silurian Anticlines.

Six great anticlinal arches traverse this area, as shown on the accompanying map, their axes extending northeast-southeast. Enumerated in the order from west to east they may be named the Wills Mountain anticline west of Cumberland, the Evitts Mountain and Tussey Mountain anticlines east of Cumberland, the Great Cacapon anticline west of Hancock, the Keefer Mountain anticline east of Hancock, and the Fairview Mountain and subordinate anticlines forming North Mountain west of Hagerstown. The erosion that has occurred since these arches were formed exposes the beds in a systematic way around each arch.

The Tuscarora sandstone outcrops at or near the center of each of these arches, forming bold and rugged mountains at many places. The younger Silurian strata surround the axes of the anticlines in V-shaped areas, each succeeding formation embracing the older in turn. The softer rocks of the folds weather into valleys, and the more resistant beds form the intervening A-shaped ridges. A cross-section through any of these


MAP
SHOWING THE DISTRIBUTION OF THE
SILURIAN FORMATIONS
OF
MARYLAND
MARYLAND GEOLOGICAL SURVEY
EDWARD BENNETT MATHEWS, State Geologist
Scale: one inch equals three miles
1922
LEGEND
Stw Tonoloway Formation
Sw Wills Creek Formation
Smk McKenzie Formation
Sc Clinton Formation { Rochester Rose Hill
St Tuscarora Formation
Sj Juniata Formation
ALLEGANY
WASHINGTON
CUMBERLAND
Hancock
Berkeley Springs
POTOMAC
RIVER
WILLS MT. ANTICLINE
EVITTS MT. ANTICLINE
TUSSEY MT. ANTICLINE
GT. CACAPON MT. ANTICLINE
KEEFER MT. ANTICLINE
NORTH MT. ANTICLINE
A. HOEN & CO. BALTO. MD.

anticlinal arches hence tends to show the accompanying topography and sequence of strata.

The Silurian strata are concealed in the synclinal areas between the arches. They are believed, however, to be continuous beneath the younger strata which cover them and so to extend westward under the younger rocks of the Alleghany Plateau.

East of North Mountain the Silurian strata have been eroded away, the surface being formed of older formations, unless indeed certain of the crystalline beds of the Piedmont Plateau may represent highly metamorphic strata of this age. These Piedmont beds are, however, unfossiliferous and hence their age cannot now be determined.

STRATIGRAPHIC AND PALEONTOLOGIC RELATIONS OF THE SILURIAN STRATA OF MARYLAND

BY

CHARLES K. SWARTZ

INTRODUCTORY

The Silurian strata of Maryland are divisible into three series that may be discriminated by their lithological character, the lower being prevailingly arenaceous, the middle argillaceous, and the upper calcareous. These divisions have been named the Medinan, the Niagaran, and the Cayugan series, respectively. They have been further subdivided into a number of formations whose relations are shown in the following table:

CAYUGAN SERIES

Tonoloway formation
Wills Creek formation
  Bloomsburg sandstone member at base
McKenzie formation

NIAGARAN SERIES

Clinton group
Rochester formation
  Keefer sandstone member at base
Rose Hill formation

MEDINAN SERIES

Tuscarora formation

The underlying Juniata red sandstone has been considered by many students to be of Silurian age, but is referred to the Ordovician system in the Ordovician monograph of the Maryland Geological Survey which should be consulted for a discussion of its relations.

The stratigraphic and paleontologic relations of the Silurian formations will now be considered in the order of their age from the oldest to the youngest.

MEDINAN SERIES

TUSCARORA FORMATION

NAME.—The Tuscarora formation was named by Darton[1] from the Tuscarora Mountains of Pennsylvania where it is finely exposed.

CHARACTER AND THICKNESS.—The Tuscarora formation consists of beds of massive white sandstone with a few thin layers of interbedded shale, the latter being found chiefly in the upper part of the formation. The sandstone consists chiefly of pure, rounded quartz grains bound together by a silicious cement, the whole being composed of nearly pure silica.

Most of the beds are very hard and compact. Upon weathering they break into great boulders and large fragments that strew the steep hill sides. At a few localities the uppermost strata disintegrate to form sand which is quarried for commercial use, as in the vicinity of Cumberland.

The thickness of the formation varies from 60 feet in North Mountain to 380 feet in the vicinity of Cumberland.

FAUNAS.—The Tuscarora formation of Maryland is sparingly fossiliferous, only three species having been observed in it, all of which are restricted to the upper beds. The most abundant species in the formation is *Arthrophycus alleghaniensis,* a trail resembling a seaweed, which covers the under sides of beds of sandstone with its numerous interlacing "stems." A worm boring, *Scolithus verticalis,* occurs rarely in the uppermost strata, and *Camarotœchia neglecta* has been observed in the beds of shale that are interstratified with the sandstone near the Clinton-Tuscarora boundary.

TOPOGRAPHIC FORM.—The Tuscarora sandstone is very resistant to weathering and gives rise to a rugged topography, its outcrop being marked by conspicuous hills and, in many places, by high and rugged mountains with steep, wooded sides. Streams, flowing across these mountains, tend to cut steep-walled gorges which in some cases strikingly resemble the canyons of the west, as at "the Narrows" through Wills Mountain at Cumberland.

[1] Darton, N. H., U. S. Geol. Survey, Folio 32, 1896.

TUSCARORA-JUNIATA BOUNDARY.—The lowest beds of the Tuscarora formation are tinged red at places, so that it is difficult to draw a sharp line of demarkation between this formation and the underlying red Juniata sandstone. In mapping the formations the plane of division has been drawn at the horizon at which the change of color is most rapid.

NIAGARAN SERIES—CLINTON GROUP

ROSE HILL FORMATION

NAME.—Vanuxem[1] named the Clinton formation from the exposure of its strata at Clinton village in central New York. The Clinton beds were subsequently correlated by Hall[2] and other students of the geology of western New York with strata that lie between the Medina sandstone and Rochester shale in that area. It has been recently shown by Ulrich[3] that the upper beds at Clinton contain species which prove, in his opinion, that the upper part of the Clinton is of Rochester age. According to this view the term Clinton has been applied to different units in different areas, embracing the pre-Rochester-Clinton in western New York and both the Rochester and pre-Rochester-Clinton at the type locality.

If Ulrich's views are accepted it might seem possible to restrict the term Clinton, on behalf of simplicity, to the pre-Rochester portion of the section at the type locality and thus to bring its significance into harmony with the long standing usage of the text-books. The name Clinton has, however, long been used commercially for iron ores that are found in both the Rochester and pre-Rochester beds at Clinton as interpreted by Ulrich. In view of these facts it has seemed best to the Committee on Geologic Names of the United States Geological Survey to embrace all the beds of the type section, including both the Rochester and the pre-Rochester beds, in the single term Clinton which would thus become a group name. The pre-Rochester strata to which the term Clinton has been so long applied in the literature are thus left without a name.

[1] Vanuxem, Lardner, Geol. New York, pt. iii, 1842, pp. 79-90.
[2] Hall, James, Geol. New York, pt. iv, 1843, pp. 18, 58-79.
[3] Ulrich, E. O., Bull. Geol. Soc. Amer., vol. xii, 1911, pl. xxviii, and quoted by Stose in U. S. Geol. Survey, Folio 179, 1912, field ed., p. 37.

Chadwick, who has made a recent critical study of the problem in New York, arrives at a very different conclusion.[1]

In view of the question which has thus arisen as to the significance of the term Clinton in New York, it has seemed best to apply a new name to the Maryland equivalents of the pre-Rochester-Clinton of New York. It is therefore here designated the Rose Hill formation from Rose Hill, Cumberland, Maryland, where its strata are finely exhibited.[2] It may be defined as follows:

The Rose Hill formation comprises all the beds between the top of the Tuscarora and the bottom of the Keefer sandstone in Maryland.

CHARACTER AND THICKNESS.—The Rose Hill formation of Maryland consists of shale interbedded with subordinate amounts of sandstone and a few bands of limestone. The shale is argillaceous, thin-bedded, fissile and breaks into delicate, parallel-sided plates. Its prevailing color is drab or olive but certain of the upper beds are pink or have a reddish tone, due to the presence of iron oxide. The sandstone is argillaceous and usually forms thin bands, save near the base of the formation, where it is thicker-bedded, being more or less transitional to the underlying Tuscarora sandstone. A few thin bands of limestone are present, occurring chiefly in the upper strata.

The thickness of the Rose Hill of Maryland varies from 300 feet in North Mountain to 550 feet near Cumberland.

SUBDIVISIONS.—This formation may be divided in Maryland into three parts, which differ lithologically, as follows:

Upper shale beds with some purplish bands
Cresaptown iron sandstone
Lower shale and sandstone beds.

The lower shale and sandstone beds consist of fissile, olive-green shales and some beds of arenaceous shales with thin beds of sandstone in their lower part. They are about 175 feet thick at Cumberland.

[1] Bull. Geol. Soc. Amer., vol. xxix, 1918, p. 327 *et seq.*

[2] Rose Hill extends southwest from Wills Creek running parallel to Wills Mountain from which it is separated by a shallow valley. It may be said to terminate at the sharp bend of the Potomac River on the outskirts of the city. The typical section is exhibited in the cut of the Western Maryland Railway, south of Wills Creek, just east of "The Narrows" through Wills Mountain.

Cresaptown Iron Sandstone.—A conspicuous feature of this formation is an iron-rich sandstone or lean "iron ore" that is especially well developed in the western part of the area where it is found about 175 feet above the base of the formation. This sandstone is well shown at Cresaptown, Maryland, 6 miles southwest of Cumberland, from which locality it is named. It has a deep-red color and consists of quartz grains cemented by hematite. Some of the beds are distinctly oölitic. The more ferruginous beds resemble a low-grade iron ore but the proportion of silica is too great to permit of their use as a commercial source of iron at the present time, as is shown by the following analyses of specimens from Cresaptown and Cumberland:

	Cumberland	Cresaptown		Cresaptown
Fe	22.75	24.84		22.40
SiO_2	59.06	47.65		71.27
Al_2O_3	3.94	2.68		3.28
Mn	.14	.29		.01
S	.07	.03		—
P	.24	.22		.08
Ignition	2.91	7.21	Alk	.17
			MgO	.60
	99.11	82.92	CaO	.58
				98.67

Interbedded with the iron sandstone are variable amounts of shale. This bed is found wherever its horizon outcrops upon the surface and forms a conspicuous feature in the topography of the western area. Similar beds of ferruginous sandstone are found in the upper part of the formation in the eastern exposures but they are usually not so rich in iron and seem to lack the persistency and constancy of position of the Cresaptown iron sandstone. Whether they represent the same horizon as the latter cannot be confidently affirmed. The Cresaptown iron sandstone attains a thickness of over 30 feet at Pinto. It is 10 feet thick at Cumberland.

The upper shale beds consist of fissile argillaceous shales that break into thin flat plates and are often purplish or pink in tone, suggesting in this respect the purple shale of the Clinton of New York.

FAUNAS.—The Rose Hill formation contains 32 species, other than ostracods, 11 of which are new. It also contains 26 species of ostracods of which 25 are new. Among its most important non-ostracod forms are *Cœlospira hemispherica, C. sulcata, Camarotœchia neglecta, Chonetes novascoticus, Tentaculites minutus, Orthoceras bassleri, Calymmene niagarensis, C. macrocephala, C. cresapensis* and *Liocalymmene clintoni.* The entire assemblage may be termed the *Cœlospira hemispherica* fauna because of the abundance and importance of that species which ranges throughout the formation.

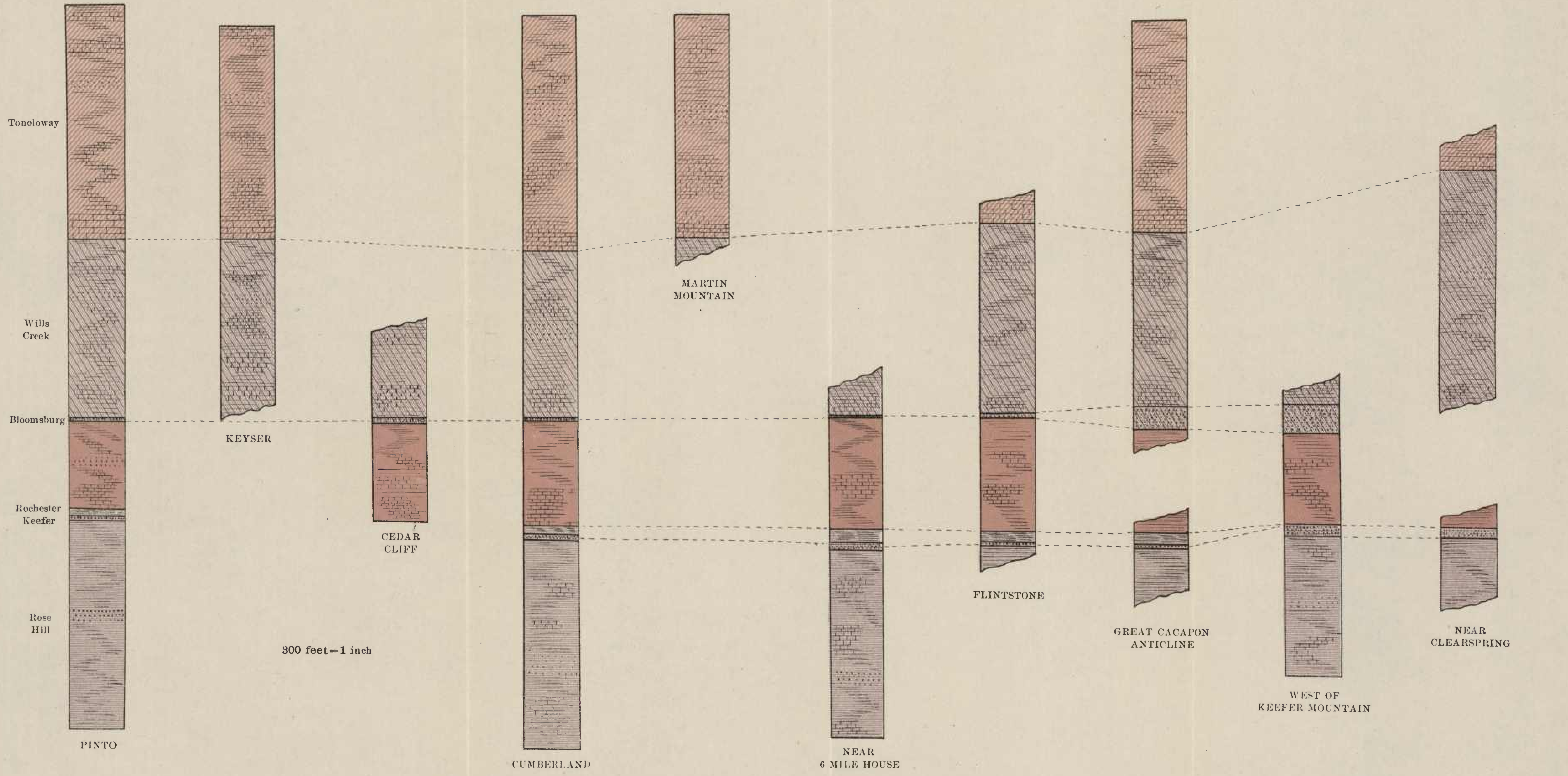
Four faunal zones, based upon species other than ostracods, may be recognized in the Rose Hill formation as follows:

Top
Liocalymmene clintoni zone
Upper barren zone
Calymmene cresapensis zone associated with the Cresaptown iron sandstone
Lower barren zone
Bottom

The beds termed the upper and lower barren zones contain few fossils other than ostracods. The other zones are much more richly fossiliferous, and contain many species in common. The upper zone is especially characterized by an abundance of *Liocalymmene clintoni* with which are associated *Tentaculites minutus, Chonetes novascoticus, Schuchertella tenuis, Cœlospira hemispherica,* etc. In addition to these non-ostracod zones Ulrich and Bassler recognize other faunal zones based upon the ostracods as given below.

The relations of the faunal zones and lithological subdivisions are shown in the following table:

Faunas			
General fauna	Non-ostracod zones	Ostracod zones	Members
Cœlospira hemispherica fauna	*Liocalymmene* zone	*Mastigobolbina typus* zone	Upper shale zone
	Upper barren zone	*Bonnemaia rudis* zone *Zygosella postica* zone *Mastigobolbina lata* zone	
	Calymmene cresapensis zone	*Zygobolbina emaciata* zone	Cresaptown iron sandstone
	Lower barren zone	*Zygobolbina decora* zone *Zygobolbina anticostiensis* zone	Lower shale zone



COLUMNAR SECTIONS OF THE SILURIAN OF MARYLAND

TOPOGRAPHIC FORM.—The base of the Rose Hill formation lies high upon the flanks of the mountains formed by the underlying Tuscarora sandstone. The Cresaptown iron sandstone forms a series of well-defined knobs that flank the Tuscarora Mountains as foothills or merge in the general slope of the mountains. The upper shale division generally occupies the floors of a well-defined system of valleys that lie between the Tuscarora Mountains and the low ridges formed by the Keefer sandstone.

THE ROSE HILL-TUSCARORA BOUNDARY.—The boundary between the Rose Hill and Tuscarora formations is concealed at most localities by a heavy overburden of sandstone blocks that descend upon it from the steep Tuscarora slopes. Where well exposed, as at the east end of "The Narrows" at Cumberland, the lower part of the Rose Hill formation is seen to be composed of numerous alternating beds of shale and sandstone, although some thin beds of shale are also present in the upper part of the Tuscarora sandstone. It is evident, therefore, that the Rose Hill and Tuscarora formations are connected by more or less transitional beds and that the formations are conformable. The basal sandstones of the Rose Hill are, however, more argillaceous than those of the underlying Tuscarora, the latter being whiter, harder, and more resistant to the weather. The plane of division between these two formations has been drawn where this transition is most marked.

ROCHESTER FORMATION

NAME.—The Rochester formation was named by Hall[1] from Rochester, New York, where it is exposed along the Genesee River.

CHARACTER AND THICKNESS.—The Rochester formation is formed of two very dissimilar lithological divisions, an upper, consisting of interbedded calcareous shale and gray crystalline limestone, and a lower massive sandstone known as the Keefer sandstone member. A bed of iron ore lies immediately above the sandstone in the western part of the area.

The upper shale is calcareous, drab in color, fissile, and breaks into thin parallel-sided plates which readily disintegrate to form a fertile soil.

[1] Hall, James, Geol. Rept. 4th Dist. of New York for 1838, 1839, p. 289.

Interstratified with the shale are numerous thin beds of limestone, most of which are crystalline, highly fossiliferous, and very lenticular. Upon weathering they become iron-stained in many cases and break into irregular pieces, upon the edges of which fossils are seen to stand out as in a coquina. The uppermost beds consist in many places of limestone which is denser and thicker bedded than the lower beds, dark-gray to black in color, and very irregularly bedded. The sandstone member, which constitutes the lower division of the formation, is more fully described below.

The thickness of the formation, including the Keefer sandstone, varies from 45 feet at Cumberland to 20 feet in North Mountain.

SUBDIVISIONS.—The Rochester formation is divisible into the following lithological units:

Upper shale and limestone
Roberts iron ore
Keefer sandstone member

The Keefer Sandstone Member.—The Keefer sandstone member should be considered an independent formation and would be so treated here were it not too thin to be mapped separately. It has hence been considered a member of the Rochester formation in this area.[1] It is named from its occurrence in Keefer Mountain, a few miles northeast of Hancock, where it forms a thick and massive bed.[2] It is a pure quartzitic sandstone in the east sections but in the western part of the area its upper beds are calcareous, or may even form an arenaceous limestone locally. Upon exposure to the weather the beds of the calcareous phase break into rather soft blocks which frequently become iron-stained. Locally it contains lenses of limestone which are very fossiliferous, as in the vicinity of Flintstone. Local uneonformities oeeur in the similar sandstone beneath the Keefer west of Hancock which contains interbedded lenses of dark,

[1] The underlying shale beds contain a species of Dalmanites which Ulrich, in the Pawpaw-Hancock Folio, referred to *D. limulurus*, leading him to place the Rochester *beneath* the Keefer. The subsequent discovery of the Rochester fauna above the Keefer and of characteristic upper Rose Hill ostracoda in the beds in question show that the latter are to be referred to the Rose Hill.

[2] This bed was first described in the Pawpaw-Hancock Folio of the U. S. Geological Survey, where it was placed at the base of the McKenzie formation. Folio 179, 1912, field edition, p. 38.

arenaceous shale. The character of this sandstone is subject to rapid variation along the strike in the latter vicinity.

This member becomes increasingly coarse and arenaceous eastward until in North Mountain it forms a hard conglomeratic sandstone which so closely resembles the beds of the underlying Tuscarora formation that it has at times been confused with the latter. It may be distinguished from the Tuscarora by the fact that it is penetrated, at many localities, by numerous short tubes of *Scolithus keeferi* which always stand at right angles to the bedding planes.

The thickness of this member increases eastward where its upper beds appear to replace successively higher and higher strata of the overlying shale until in North Mountain it seems to constitute the entire Rochester formation. It is 11 feet thick at Cumberland, 20 feet thick in the vicinity of Hancock,[1] and 20 to 35 feet thick in North Mountain.

The Roberts Iron Ore.—In Allegany County the Keefer sandstone is immediately overlain by a bed of iron ore for which the name Roberts iron ore is here proposed from Roberts station at the south end of Rose Hill, south of Cumberland, where it is well exposed. The ore is hematite, frequently oölitic, and contains numerous poorly preserved fossils. It attains a thickness of about 1 foot in the vicinity of Cumberland where it is of excellent quality and has been extensively worked in the past as a source of iron though it is now largely exhausted. It has not been observed east of Tussey Mountain.

A sample from "The Narrows," east of Wills Mountain at Cumberland, shows the following composition[2]:

Fe	37.37
SiO_2	15.05
Al_2O_3	9.89
CaO	9.09
MgO	.93
Mn	.30
S	.06
P	.51
Ignition	10.41

[1] The Keefer sandstone is underlain by thick argillaceous sandstones near Hancock, from which it appears to be separated by an unconformity. The latter sandstones are referred to the Rose Hill in this volume.

[2] Singewald, J. T., Jr., Iron Ores of Maryland, Md. Geol. Survey, vol. ix, 1911, p. 296.

The upper shale and limestone, which has been already described, attains its maximum development in the vicinity of Cumberland where it is about 35 feet thick. It is replaced in increasing measure by the underlying sandstone eastward until in the vicinity of Hancock it is about 2 to 3 feet thick. It is absent east of that place.

FAUNAS.—The Rochester formation contains a large fauna which is rich in specimens and individuals, comprising 62 species other than ostracods, 29 of which are new. It also contains many ostracods. Many of the limestone lenses in this formation are so profusely fossiliferous as to form a veritable coquina. The whole assemblage may be called the *Dalmanites limulurus* fauna from the abundant occurrence and wide-spread distribution of that species, whose typical form is restricted to this horizon in Maryland.[1] With it are many other species including *Homalonotus delphinocephalus, Pholidops squamiformis, Rhipidomella hybrida, Stropheodonta corrugata, Camarotœchia neglecta, Atrypa reticularis, Spirifer crispus, S. radiatus, S. niagarensis, Trematospira camura, Pterinea emacerata, Bucanella trilobata,* and *Tentaculites niagarensis.*

Four faunal zones, based upon species other than ostracods, may be discriminated in the Rochester formation as follows:

Top
Whitfieldella marylandica zone
Schuchertella tenuis zone
Uncinulus stricklandi zone
Liocalymmene clintoni zone in Keefer sandstone
Bottom

Ulrich and Bassler also recognize ostracod zones in the formation.

The *Liocalymmene clintoni* zone occurs near the base of the Keefer sandstone and is characterized by that species associated with *Dalmanites limulurus.* Immediately overlying the latter sandstone is a thin zone

[1] A species of Dalmanites closely resembling *Dalmanites limulurus* occurs in the upper shale beds beneath the Keefer sandstone. Stose and Ulrich identified this as *D. limulurus* in their discussion of the Rochester formation in the Pawpaw-Hancock folio, and hence included the upper part of the Rose Hill of this volume in their Rochester. Ulrich and Bassler now recognize the pre-Rochester age of these beds and consider the Rose Hill Dalmanites specifically distinct.

carrying a profusion of *Uncinulus* cf. *stricklandi* associated with other species. *Schuchertella tenuis* is restricted to a thin zone a short distance below the top of the formation. The *Whitfieldella marylandica* zone is found at the top of the formation, shells of this species occurring at many places in such profusion as to constitute a large part of some of the beds. The species found in various zones are listed more fully in the table of distribution.

No fossils save *Scolithus keeferi* have been observed in the Keefer sandstone in the eastern sections. In the central part of the area, however, it contains limestone lenses that are locally fossiliferous, as at Flintstone, where it contains *Dalmanites limulurus,* and many other species, showing its Rochester age.

The relations of the faunal and lithological divisions is shown in the following table:

Faunas		
General fauna	Faunal zones	Lithology
Dalmanites limulurus fauna	*Whitfieldella marylandica* zone *Schuchertella tenuis* zone *Uncinulus stricklandi* zone	Upper shale and limestone beds Roberts iron ore
	Liocalymmene clintoni zone	Keefer sandstone member

TOPOGRAPHIC FORM.—The Keefer sandstone forms a well-defined ridge which may be traced throughout the entire area wherever its rocks outcrop, becoming increasingly prominent eastward. The upper shale and limestone disintegrate readily upon exposure to the weather and, together with the easily eroded McKenzie formation, occupy the floors of fertile valleys which lie between the Keefer and Bloomsburg sandstones.

ROCHESTER-ROSE HILL BOUNDARY.—The base of the Rochester formation has been uniformly drawn at the base of the Keefer sandstone.

CAYUGAN SERIES

McKENZIE FORMATION

NAME.—The McKenzie formation derives its name[1] from McKenzie station on the Baltimore and Ohio Railroad, 9 miles southwest of Cumberland.

[1] U. S. Geol. Survey, Folio No. 179, field edition, 1912, p. 46.

CHARACTER AND THICKNESS.—The McKenzie formation consists chiefly of interbedded shale and argillaceous limestone. The shale is drab, fissile, calcareous, and breaks into thin parallel-sided plates that readily weather to a fertile soil. The limestone is lenticular, usually thin bedded, and many of its courses are dark and granular. Some layers contain large numbers of flattened limestone pebbles, the color of which differs from that of the surrounding matrix, rendering them conspicuous objects. The beds become more arenaceous towards the top of the formation which, in the Cumberland area, is usually formed by an argillaceous sandstone. Some thin beds of sandstone are also found at other horizons in the formation in the eastern exposures, where thick red beds are also present.

The thickness of the McKenzie formation is approximately 240 feet.

SUBDIVISIONS.—The following lithological subdivisions are recognizable in the McKenzie formation in Maryland:

Top

Arenaceous shale and interbedded limestone, forming the top of the formation. Some red beds are present in this unit in the eastern exposures.
Upper calcareous shale and argillaceous limestone.
Rabble Run red sandstone member.
Lower calcareous shale and argillaceous limestone, becoming dark and thicker bedded near bottom of formation.

Bottom

Lower Calcareous Shale and Argillaceous Limestone.—The base of the formation is formed at many places of a dark to black rather thick-bedded argillaceous limestone which has very irregular bedding planes. These basal beds cannot be confidently distinguished by their lithology from the underlying strata that form the top of the Rochester formation. They are overlain by more argillaceous strata consisting of interbedded shale and limestone.

Rabble Run Red Sandstone Member.—One of the conspicuous features of the formation is the presence of red beds about 100 feet below the top of the formation in Washington County. These red strata have not been observed in the western sections, but in passing eastward they make their first appearance in the Cacapon Mountain west of Hancock as thin tongues of red strata but a few feet thick, separated by gray bands. Farther east they increase in thickness until they finally merge to form one nearly continuous mass of red beds that attain a thickness of nearly 100 feet on Rabble Run in North Mountain. These beds closely resemble those of the overlying Bloomsburg red sandstone. Red strata also appear in the upper beds of the formation in the eastern exposure, so that it is difficult to draw a sharp line between the McKenzie and Bloomsburg in North Mountain.

The thickening of the red beds eastward accompanied by the thinning of the marine strata of the McKenzie and the intimate intertonguing of both leave little doubt that they are all of the same age. Farther east therefore the McKenzie may be expected to vanish and the whole interval be replaced by red beds which would be referred to the Bloomsburg. In other words, the McKenzie is a marine phase of part of the Bloomsburg and bears the same relation to the latter as the Chemung does to the Catskill.

Beds similar to the basal strata lie above the Rabble Run red beds. A peculiar dark, arenaceous shale, penetrated by large numbers of fine, tubular branching borings, filled with sand, constitutes a conspicuous feature near the top of the formation in the western exposures. This is overlain in the vicinity of Cumberland by arenaceous shale and shaly sandstone which grades into the overlying sandstone at the base of the Wills Creek formation.

FAUNA.—The fauna of the McKenzie formation consists largely of new species. It comprises 34 species, other than ostracods, of which 13 are new. It also contains 38 species of ostracods, most of which are new.

Most of the strata of the formation contain fewer fossils, other than ostracods, than those of the underlying Rochester. Some beds, however, especially those in the middle and upper part of the formation, contain a great profusion of such organisms. Ostracods occur in great numbers in this formation, constituting a large part of some strata.

Three chief faunal zones, based upon species other than ostracods, may be discriminated in the McKenzie formation as follows:

Top
Camarotoechia andrewsi zone including the
Uncinulus obtusiplicatus subzone
Homatoma-Orthoceras zone
Reticularia bicostata zone
Bottom

The lowest zone contains numerous *Reticularia bicostata* and *R. bicostata* var. *marylandica,* associated with *Leptæna rhomboidalis, Stropheodonta corrugata* and *S. corrugata* var. *pleuristriata,* all of which are restricted to this horizon. *Whitfieldella marylandica* is also abundant in this zone and rare at higher horizons. Fossils are most numerous in the lower beds of this zone.

A great profusion of gastropods especially of the genus Homatoma associated with the cephalopod *Orthoceras mackenzicum* are found in a zone near the middle of the formation. The shells of these species occur in such profusion in the rock near Cumberland and the Six-Mile House east of Cumberland that they form a veritable coquina. This zone also contains *Lingula subtruncata* and *Oncoceras mackensicum* as well as other species not restricted to it.

Camarotœchia andrewsi occurs in great profusion in a zone extending from 30 to 100 feet beneath the top of the formation. Lying in this horizon about 50 feet beneath the top of the formation, is a narrow subzone, the *Uncinulus obtusiplicatus* subzone which bears a large number of species, all of which are restricted to it, including *Uncinulus obtusiplicatus, Lingula clarki, Spirifer mackenzicus, Trematospira camura, Cuneamya ulrichi, Poleumita mackenzica, Tentaculites niagarensis, T. niagarensis* var. *cumberlandicæ, Corydocephalus ptyonurus, Calymmene niagarensis* var. *restricta,* and *C. macrocephala. Dalmanella elegantula* is also common at this horizon though it is not restricted to it.

The relations between the lithology and faunal zone is shown in the following table:

Faunal zones	Lithology
Camarotoechia andrewsi zone	Upper calcareous shale and limestone beds
Uncinulus obtusplicatus subzone 50 feet below top of formation	
	Rabble Run red beds (in east)
Homatoma-Orthoceras zone about middle of formation	Lower calcareous shale and limestone beds
Reticularia bicostata zone	
Erosional unconformity	

TOPOGRAPHIC FORM.—The strata of the McKenzie formation disintegrate readily upon weathering to form a fertile soil, occupying valleys which lie between the ridges capped by the more resistant Keefer and Bloomsburg sandstones.

MCKENZIE-ROCHESTER BOUNDARY.—The Keefer sandstone was included in the McKenzie formation by Ulrich and Stose[1] in the area embraced in the Hancock Folio of the U. S. Geological Survey and the base of the McKenzie formation was placed at the top of the beds containing the Rochester fauna in the region about Cumberland by the same authors. Subsequent investigation by Prouty and the author have established the presence of the Rochester fauna both in and above the Keefer sandstone in the Hancock area and a critical study of closely placed sections has shown that this sandstone is to be correlated with the similar bed at the base of the Rochester formation in the western exposures[2] as have been done in this volume. The Keefer sandstone is here included in the Rochester formation while the base of the McKenzie is placed at the top of the strata containing the Rochester fauna.

As thus defined, the lower strata of the McKenzie formation cannot be discriminated lithologically from the upper beds of the Rochester formation. Both are parallel and appear conformable. Although a number of species, other than ostracods, pass from the Rochester into the base of the McKenzie, the species of ostracods change abruptly at the boundary between the formations, according to the identifications of Ulrich, who is thus led to believe that a hiatus exists between the McKenzie and Rochester formations and hence that they are unconformable. The lower limit of the formation is therefore based upon paleontological criteria, especially upon that furnished by the ostracods, rather than upon the differences of lithology. The line between the formations has been drawn upon the geological map by setting off known stratigraphic distances above the Keefer sandstone, which has been employed as a datum plane.

[1] U. S. Geol. Survey, Folio No. 179, field edition, 1912, p. 38.
[2] Geol. Soc. Amer. Bull., vol. xxvii, 1916, p. 89.

WILLS CREEK FORMATION

NAME.—The Wills Creek formation receives its name from Wills Creek, Cumberland,[1] where its strata were formerly well exposed along the creek at the cement works east of "The Narrows."

CHARACTER AND THICKNESS.—The Wills Creek formation overlies the McKenzie formation conformably. It consists of interbedded calcareous shale, calcareous mud rock, and argillaceous limestone with several beds of sandstone. When seen in fresh exposures many of the strata seem to consist of compact dark, purplish-blue, medium-bedded limestone that appears to possess considerably durability. Brief exposure to the weather, however, changes the color of these strata to a dirty greenish tone and causes them to disintegrate into a calcareous shale that breaks into small angular greenish fragments bearing no resemblance to the fresh rock. This feature is due to the large amount of clay manifestly present in the rock. Other strata consist of thick-bedded, calcareous mud rocks that present little evidence of lamination and become buff-colored upon exposure to the weather. Alternating with these rocks are beds of calcareous shale, some of which are thin-bedded, fissile, and at certain horizons dark-colored. With these highly argillaceous strata are a few beds of purer limestone that do not disintegrate so readily. The latter are more conspicuous in the lower part of the formation.

Some of the strata have a composition such that they form natural cement when burned. Four such beds have been worked at Pinto. Similar beds were burned into cement at Cedar Cliff, West Virginia, and at Cumberland and Round Top, 3 miles west of Hancock, Maryland. The beds employed for this purpose are argillaceous limestones and calcareous shale frequently marked by mud cracks ("Turtle-back rock"). The cement rocks do not occupy constant positions in the formation, but occur at different horizons at different localities.

Beds of sandstone are found at two well-defined horizons in the formation. Red beds occur at many stratigraphic positions in the eastern

[1] U. S. Geol. Survey, Folio 179, field edition, 1912, p. 51. The true type locality of the formation may be considered to be the section on the Baltimore and Ohio Railroad at Pinto but the latter name was preoccupied as a designation of this formation.

exposures where they impart a strikingly variegated appearance to the formation.

The surfaces of many of the strata are covered by mud cracks and some are ripple-marked and the entire formation gives evidence of having been accumulated in quiet, shallow waters. Imprints of salt crystals are found just below the top of the formation at many localities in the Cumberland area.

The thickness of the Wills Creek formation varies from 450 feet to 500 feet. In North Mountain one measurement appears to give a thickness of a little over 600 feet.

SUBDIVISIONS.—The following lithologic divisions can be recognized in this formation:

Upper shale and limestone beds with imprints of salt crystals near top
Upper sandstone
Middle shale and limestone beds
Lower sandstone
Lower shale and limestone beds with some interbedded sandstone
Bloomsburg red sandstone member comprising three divisions:
- Upper red beds
- Cedar Cliff limestone lens
- Lower red beds

Bloomsburg Red Sandstone Member.—The Bloomsburg red sandstone member is a distinct lithological and stratigraphic unit and should be considered a separate formation. The western extension of the Bloomsburg is, however, too thin to permit mapping it separately and for this reason only it is here treated as a division of the Wills Creek formation. Where it is thick enough to permit mapping it should be discriminated as a separate formation and the term Wills Creek restricted to the overlying beds. The relations of the Bloomsburg to the McKenzie and Wills Creek are like those of the Catskill and the Chemung and will be discussed more fully in the chapter on correlation.

This member is distinguished from the overlying strata of the Wills Creek formation by the deep-red color of its rocks. It was named[1] the

[1] White, I. C., Second Geol. Survey of Penn., vol. G7, 1883, p. 106.

Bloomsburg sandstone by I. C. White from its typical occurrence at Bloomsburg, Columbia County, Pennsylvania. It consists of interbedded sandstone and arenaceous shale, both of which are colored blood-red by disseminated hematite. Interbedded with the red beds are some bright-green strata. Certain beds also display green lines situated at right angles to the bedding planes. The material composing these lines consists locally of calcareous nodules which undergo solution and produce porous, discontinuous, tubular cavities. Other beds lose their red color along the bedding planes or more rarely along the joints which become yellowish-green. Most of the beds, however, retain their bright color even upon prolonged exposure to the weather. A few bands of hard, white sandstone are found in this member at some of the eastern localities. In some of the western localities the red color is lacking in the lowest beds, as at Pinto, where the base of the formation consists of hard gray sandstone. That this gray sandstone is part of the Bloomsburg is clearly shown by its stratigraphic relations to the red sandstone farther north.

A conspicuous feature of the member is a hard blue, or in places pink, limestone which is found between the lower and upper red beds. Some of the basal strata of the limestone consist of nodules and resemble a conglomerate. Upon exposure the limestone becomes yellow and disintegrates in places, as at Pinto, where it was called by Schuchert the "disintegrated rock."[1] This limestone thickens westward and thins eastward. It can be traced throughout the region from Keyser on the west to Hancock on the east. It may be represented by lead-colored shales east of the latter point. The name Cedar Cliff limestone is suggested for this bed from Cedar Cliff, Maryland, a station on the Baltimore and Ohio Railroad southwest of Cumberland, where it is well exposed.

The thickness of the Bloomsburg member varies from 20 feet in the west to 200 feet in the east.

Red strata similar to those of the Bloomsburg also occur at various horizons in the Wills Creek above the top of the Bloomsburg member in the eastern exposures. In passing eastward from Cumberland these

[1] Schuchert, Charles, On the Lower Devonic and Ontaric Formations of Maryland. Proc. U. S. Nat. Mus., vol. xxvi, 1903, p. 423.

strata are first observed a short distance above the Bloomsburg member in the Cacapon Mountain anticline. They appear at successively higher and higher elevations farther east until a considerable part of the Wills Creek formation becomes red in North Mountain where it presents a strikingly variegated appearance and is comparable to the "variegated rock" of the Salina of Pennsylvania and New York. These geographic variations will be discussed more fully in another place.

The shale and limestone beds of the Wills Creek formation lying above the Bloomsburg member are divided into three parts by two sandstones which are found in them. At many places the lower of these sandstones consist of interbedded arenaceous shale and interbedded sandstone and is found about 275 feet above the base of the formation. The upper bed, which is situated about 80 feet beneath the top of the formation, is thin but very persistent. Both beds increase in thickness eastward where their outcrop is marked by lines of hills.

FAUNAS.—The Wills Creek formation contains few fossils other than ostracods. The latter occur, however, in such abundance that some of the beds are composed almost entirely of their remains. Among the most important forms, other than ostracods, are *Spirifer vanuxemi, Camarotœchia litchfieldensis, Schuchertella interstriata, Uncinulus marylandica, U. obsolescens,* and *Calymmene camerata.*

No fossils have been found in the red beds of the Bloomsburg member save a few valves of species of Lingula and fragments of fish scales. Species of Leperditia occur, however, in the Cedar Cliff limestone.

Four faunal zones may be recognized in the formation as follows:

Top
Eurypterid zone
Upper ostracod zone
Spirifer vanuxemi zone
Lower ostracod zone
Bottom

The *Spirifer vanuxemi* zone is the most important stratigraphic horizon in the entire formation. Though thin it abounds in fossils, containing many *Spirifer vanuxemi* and *Camarotœchia litchfieldensis* associated with *Calymmene camerata.* This horizon may be traced about 235 feet above the base of the formation from Keyser on the west to Hancock on the east.

The Eurypterid zone is found near the top of the formation in the vicinity of Cumberland where a number of beautifully preserved specimens and fragments have been found in rocks so closely resembling those containing Eurypterid fauna at Buffalo, New York, that it is difficult to distinguish them lithologically. Leperditias are among the most abundant ostracods, appearing in numbers in the Cedar Cliff limestone and ranging upwards through the formation into the overlying Tonoloway.

The relations of the lithology and faunal zones is shown in the following table:

Faunal zones	Lithology
Eurypterid zone	Upper shale and limestone
	Beds with imprints of salt crystals
	Upper sandstone
Upper ostracod zone	Middle shale and limestone
Spirifer vanuxemi zone	
	Lower sandstone
Lower ostracod zone	Lower shale and limestone
	Bloomsburg red sandstone

TOPOGRAPHIC FORM.—The Bloomsburg red sandstone forms a conspicuous ridge that rises out of the broad valley formed by the shale and limestones that lie between the higher elevations of the Tuscarora and Oriskany sandstones. It runs parallel to a similar ridge formed by the Keefer sandstone. The soil formed by the Bloomsburg sandstone is poor and rocky and hence but little cultivated, the outcrop being conspicuous by the line of trees that stand out upon its crest in the midst of cultivated fields.

Most of the strata above the Bloomsburg are soft and weather readily and completely to soil. They hence occupy the valley floor between the Bloomsburg and Oriskany. A low line of hills rises near the top of the formation, marking the position of the more resistant upper Wills Creek sandstone.

WILLS CREEK-MCKENZIE BOUNDARY.—The base of the Wills Creek formation has been drawn at the base of the persistent red beds of the

Bloomsburg sandstone member. Where the lower red beds have been replaced by gray sandstone, as at Pinto, west of Cumberland, the base of the formation has been drawn at the base of the massive gray sandstone beneath the Cedar Cliff limestone. This horizon can be followed clearly, for although the upper beds of the McKenzie are very arenaceous locally they are less massive than those of the overlying Bloomsburg. In the eastern exposures numerous tongues of red rock are interbedded with the fossiliferous, gray limestone and shale of the upper part of the McKenzie formation. Here the base of the Wills Creek formation has been drawn below the thicker and more persistent red beds and above the highest gray beds carrying the marine fossils of the McKenzie formation.[1]

TONOLOWAY FORMATION

NAME.—The Tonoloway formation received its name from Tonoloway Ridge west of Hancock, Washington County, where it is well exposed.[2]

CHARACTER AND THICKNESS.—This formation consists of interbedded argillaceous limestone and calcareous shale. The limestone is prevailingly dark-gray, hard and thin-bedded. Upon weathering it breaks into numerous small hard plates that lie in great numbers upon the surface of the ground and do not readily disintegrate into soil. Most of the beds are finely straticulate, consisting of successive dark and lighter-colored laminæ. Some of the strata are more massive and uniform in texture and others are oölitic. A few more magnesian beds are fine grained, non-laminated, break with a conchoidal fracture, and weather to a buff color. Associated with the limestone is much calcareous shale. A single bed of sandstone is found about 120 feet above the base of the formation in the eastern exposures. Most of the limestone disintegrates to form an orange-

[1] The base of the Bloomsburg red sandstone was placed at the base of the Rabble Run red beds of the McKenzie by Stose in the region east of Hancock on his map of that area in the Pawpaw-Hancock Folio 179 of the U. S. Geol. Survey, 1912. The upper part of the McKenzie with its marine fauna was thus included by him in the Wills Creek formation in that area.

[2] Pawpaw-Hancock Folio, U. S. Geol. Survey No. 179, 1912, p. 55. The true type section of the Tonoloway should be considered that exposed on the Baltimore and Ohio Railroad at Pinto but this name was preoccupied.

colored soil which differs conspicuously from the gray soil of the underlying Wills Creek.

The Tonoloway is nearly 600 feet thick throughout the State except in North Mountain, where it is thinner, perhaps due to faulting.

SUBDIVISIONS.—The following lithological sequence is recognizable in this formation:

Top
Upper argillaceous limestone
Upper calcareous shale with some interbedded limestone
Middle purer limestone beds
Indian Spring sandstone
Indian Spring red beds
Lower calcareous shale and limestone with a few imprints of salt crystals in the eastern exposures
Lower limestone, very massive
Bottom

A very massive bed of limestone has been made the base of the formation throughout the area studied. This is overlaid by calcareous shale and some interbedded argillaceous limestone, these strata differing but little from the rocks of the underlying Wills Creek. An interesting feature is the occurrence of imprints of salt crystals in these beds in section at Grasshopper Run, West Virginia. The purest and most compact limestone of the formation occurs in the division above the Indian Spring sandstone. These rocks are dense, fine grained, almost black upon fresh fracture, and sparingly fossiliferous. They are burned at many localities, yielding an excellent grade of lime, as at Cumberland, where the limestone quarries are located in them. The next overlying division consists largely of calcareous shale which attains a thickness of nearly 100 feet in the western sections, where it is a conspicuous feature, separating the quarry rock of the Tonoloway from that worked in the lower part of the Helderberg formation. Thin beds of argillaceous limestone are found at the top of the formation in the western exposures.

Indian Spring Sandstone.—A sandstone is found about 120 feet above the base of the formation which is here termed the Indian Spring sandstone from its occurrence at Indian Spring, Washington County, Maryland. This bed is thin and inconspicuous at Pinto, but increases in

FIG. 1.—VIEW LOOKING WEST UP THE POTOMAC FROM CACAPON MOUNTAIN, SHOWING TOPOGRAPHY. TONOLOWAY RIDGE ON THE RIGHT. SIDELING HILL GAP IN THE DISTANCE.

FIG. 2.—VIEW SHOWING THE NARROWS OF WILLS MOUNTAIN WEST OF CUMBERLAND.

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thickness eastward. In the vicinity of Hancock it is argillaceous and about 5 feet thick. East of the latter point it becomes very hard, dense, and breaks into irregular fragments that strew the ground upon its outcrop. This sandstone seems to occupy the stratigraphic position of the Bloomfield sandstone of Claypole[1] found at New Bloomfield, Perry County, Pennsylvania. Red beds, here called the Indian Spring red beds, are associated with it in North Mountain, becoming conspicuous in the easternmost exposures.

FAUNA.—Ostracods occur abundantly in the Tonoloway formation, 30 species, most of which are new, having been found in it. Apart from these organisms, however, most of the beds are sparingly fossiliferous though a few strata contain a profusion of other species, especially in the western part of the area studied. Among the most abundant species, other than ostracods, in this formation are: *Hindella congregata, Rhynchospira globosa, Stenochisma lamellata, Camarotœchia litchfieldensis, Spirifer vanuxemi, S. corallinensis, Schuchertella rugosa, Hormatoma rowei,* and *Tentaculites gyracanthus* var. *marylandica.*

The following faunal zones may be recognized in the formation:

Top

Spirifer corallinensis zone
Barren shale zone
Hindella congregata zone including 3 subzones as follows:
- *Hindella congregata* subzone containing a great profusion of that species
- *Stenochisma lamellata* subzone
- *Tetrameroceras cumberlandicum* subzone

Ostracod zone

Bottom

The beds below the Indian Spring sandstone constitute the ostracod zone, containing few fossils other than ostracods. The middle purer limestone beds form the *Hindella congregata* zone, that species being especially abundant in it in the western exposures. Most of the fossils, other than ostracods, recorded from the Tonoloway formation have been found in this zone, which has been divided into three subzones. The lower subzone is characterized by numerous cephalopods, including *Tetra-*

[1] Claypole, E. W., Second Geol. Survey Penn., vol. F2, 1885, p. 54.

meroceras marylandicum, T. cumberlandicum var. *magnacameratum,* and *Trochoceras marylandicum.* The second subzone, situated near the middle of the formation, is the most fossiliferous portion of the formation, containing a great profusion of *Stenochisma lamellata,* its characteristic species, associated with *Rhynchospira globosa, Camarotœchia litchfieldensis, Favosites niagarensis, Aulopora tonolowayensis, Fistuliporella tenuilamellata, Orthopora marylandensis,* and *Cyphotrypa expansa. Stromatopora constellata* occurs sparingly in this subzone in the western exposures but farther eastward it becomes more conspicuous until it forms a thick reef at this horizon in the vicinity of Hancock. *Hindella congregata* occurs in great profusion above the *Stenochisma lamellata* subzone, especially in the western sections, as at Keyser.

The *Spirifer corallinensis* zone is found in the uppermost beds of the formation and is characterized by the presence of *Spirifer corallinensis* associated with *S. keyserensis, Stropheodonta bipartita* var. *nearpassi, Camarotœchia litchfieldensis, Stenochisma lamellata, Tentaculites gyracanthus* var. *marylandicus,* and *Calymmene camerata.*

The relations of the lithology and faunal zones is shown in the following table:

Faunal zones		Lithology
Spirifer corallinensis zone		Upper argillaceous limestone Upper calcareous shale and limestone
Hindella congregata zone	Hindella congregata subzone Stenochisma lamellata subzone Tetremeroceras subzone	Middle purer limestone
Ostracod zone		Indian Spring sandstone Indian Spring red beds Lower calcareous shale and limestone Lower limestone

Topographic Form.—The Tonoloway formation lies upon the lower slopes of the hills formed by the Helderberg and Oriskany formations. The upper shale beds of the Tonoloway usually occupy a depression that separates the underlying limestone strata rather sharply from the Helderberg formation. The Indian Springs sandstone is usually found either at the top of an abrupt rise or on the crest of a low ridge formed by its outcrop.

TONOLOWAY-WILLS CREEK BOUNDARY.—The Tonoloway and Wills Creek formation are most readily distinguished by the difference manifested by the strata upon exposure to the weather. When fresh the limestone of the Wills Creek formation often appears to be as compact as that of the Tonoloway. Upon exposure, however, most of the argillaceous or calcareous beds disintegrate so completely that scarcely a fragment of rock other than sandstone remains upon the ground. A few of the lower limestone beds, however, may yield rock fragments. The limestones of the Tonoloway formation, on the contrary, break into great numbers of small, hard, dark-blue fragments that ring when struck. The Tonoloway limestone yields an orange-red soil and the Wills Creek rocks form a gray soil.

The base of the Tonoloway formation has been drawn at the base of the lowest strata, displaying these features in a well-marked manner in the western exposures. Many of the lower beds, however, are more or less transitional in character so that it is not probable that the boundary between the formations has been placed at a constant horizon. Much use has been made of the sandstone that occurs about 80 feet below the top of the Wills Creek formation in tracing the upper limit of the Wills Creek formation on the geological map of this area.

The basal portion of the Tonoloway formation becomes increasingly argillaceous eastward where many of the lower beds closely resemble those of the underlying Wills Creek formation and could justly be included in it as was done by Stose, who placed the Wills Creek-Tonoloway contact at the top of the Indian Spring sandstone in his map of the eastern part of the Hancock quadrangle.[1] This sandstone appears to lie, however, about 120 feet above the horizon selected as the Wills Creek-Tonoloway boundary in the Cumberland area. The author has for the sake of consistency drawn the lower limit of the Tonoloway forma-

[1] U. S. Geol. Survey, Folio No. 179, 1912.

tion at the base of a heavy ledge of limestone which lies at the bottom of the formation in the west and which appears to occupy a constant horizon throughout the state. Much use, however, has been made of the Indian Spring sandstone in preparing the map of the eastern region, where it is a conspicuous topographic feature.

TONOLOWAY-HELDERBERG BOUNDARY.—This boundary is sharply discriminated by the marked difference between the lower beds of the Helderberg formation and the upper strata of the Tonoloway. The former are massive, singularly nodular, lumpy limestones which are resistant to weathering and tend to form abrupt cliffs. The latter are fragile laminated limestones which disintegrate upon exposure and form gentler slopes. A single bed of compact, blue limestone about 2 feet thick and without nodules is found at the boundary between these formations at many places. It has been included in the Tonoloway formation, whose strata it resembles more closely than those of the Helderberg.

Summary.—The succession of formations, members and faunal zones of the Silurian of Maryland may be summarized in the following table:

		Lithology	Faunal Zones	Subzones
Cayugan Series.	Tonoloway Formation.	Upper argillaceous limestone.	Spirifer coraliensis.	
		Upper calcareous shale and limestone.	Hindella congregata.	Hindella congregata. Stenochisma lamellata. Tetremeroceras.
		Indian Spring sandstone.		
		Indian Spring red beds.		
		Lower calcareous shale and limestone.	Ostracod.	
		Lower limestone.		
	Wills Creek Formation.	Upper shale and limestone.	Eurypterid.	
		Beds with imprints of salt crystals.		
		Upper sandstone.		
		Middle shale and limestone.	Ostracod. Spirifer vanuxemi.	
		Lower sandstone.		
		Lower shale and limestone.	Ostracod.	
		Bloomsburg red sandstone.		
	McKenzie Formation.	Arenaceous shale and limestone.		
		Upper calcareous shale and argillaceous limestone.	Camarotoechia andrewsi.	Uncinulus obtusiplicatus.
		Rabble Run red sandstone.		
		Lower calcareous shale and argillaceous limestone.	Homatoma-Orthoceras.	
			Reticularia bicostata.	
Niagaran Series. Clinton Group.	Rochester Formation. (Dalmanites limulurus fauna).	Upper shale and limestone.	Whitfieldella marylandica. Schuchertella tenuis. Uncinulus stricklandi.	
		Roberts iron ore.		
		Keefer sandstone near base.	Liocalymene clintoni.	
	Rose Hill Formation. (Coelospira hemispherica fauna).	Upper shale beds.		
			Upper barren.	
		Cresaptown iron sandstone.	Calymmene cresapensis.	
		Lower shale and sandstone.	Lower barren.	
Medinan Series.	Tuscarora Formation.			

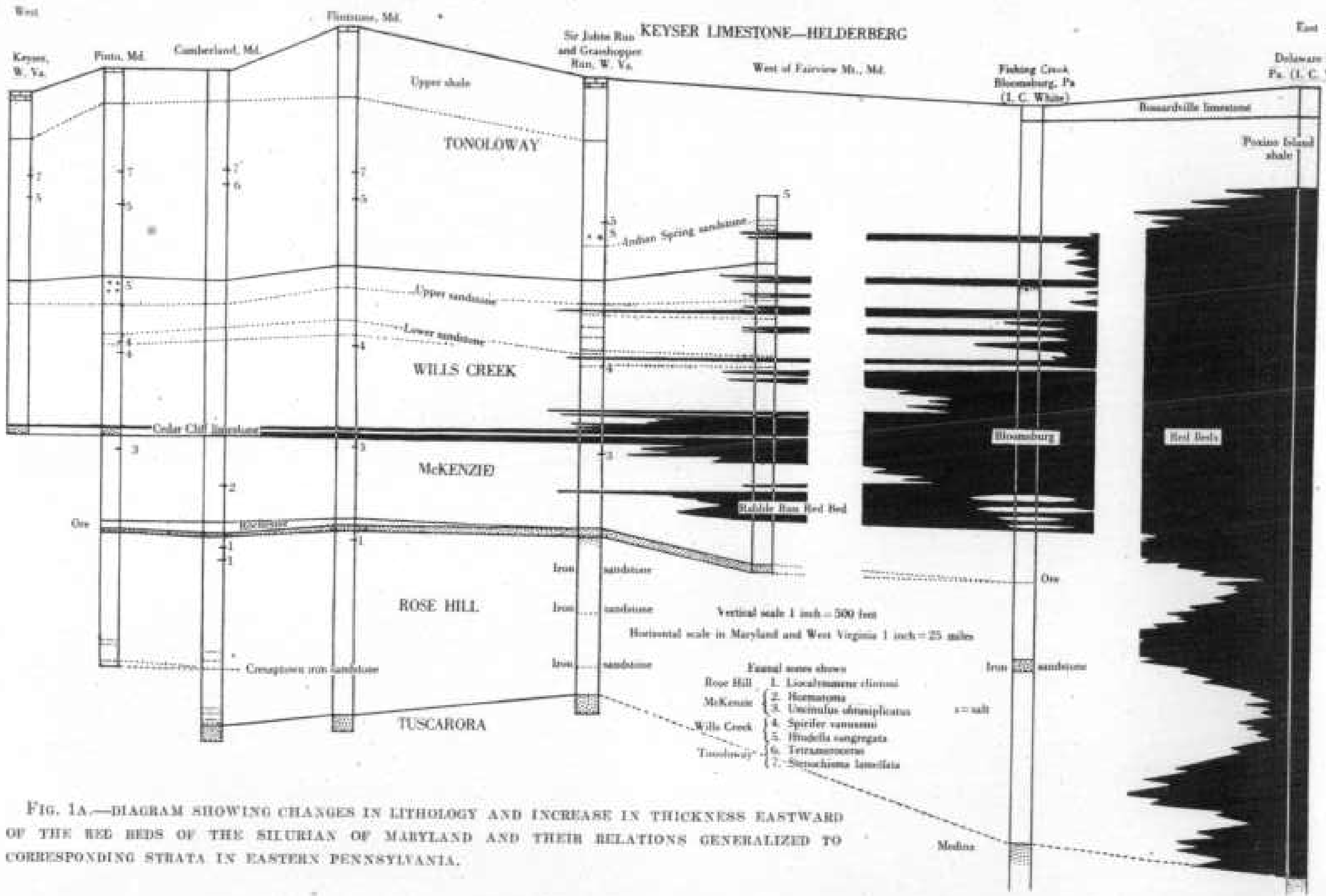

FIG. 1A.—DIAGRAM SHOWING CHANGES IN LITHOLOGY AND INCREASE IN THICKNESS EASTWARD OF THE RED BEDS OF THE SILURIAN OF MARYLAND AND THEIR RELATIONS GENERALIZED TO CORRESPONDING STRATA IN EASTERN PENNSYLVANIA.

SECTIONS OF THE ROSE HILL AND McKENZIE FORMATIONS

BY

W. F. PROUTY AND C. K. SWARTZ[1]

A. Sections in the Wills Mountain Anticline

I. Section at Pinto

The finest section of the McKenzie formation and of the upper part of the Clinton in Maryland is seen at Pinto, a station on the Baltimore and Ohio Railroad, 8 miles southwest of Cumberland. The Potomac River flows across the western limb of the Wills Mountain anticline cutting the strata, which stand nearly vertical. The natural section has been rendered still more perfect by the construction of the railroad so that an uninterrupted section is exhibited extending from the base of the Helderberg to the upper part of the Clinton, embracing the entire Tonoloway, Wills Creek, and McKenzie formations.[2]

The McKenzie and about 150 feet of the Rose Hill formation are seen in the cut west of the cement mill formerly operated at this place. The middle beds of the Rose Hill, which are much folded and largely concealed, lie in the hillside back of the mill. The Cresaptown iron sandstone and a portion of the immediately adjacent strata are exhibited in the slightly dipping and more or less folded eastern limb of the anticline, a short distance east of the mill. The Roberts iron ore is represented by a mere trace at the top of the Keefer sandstone, although it is a foot and a half

[1] The sections west of the Fairview anticline were described by the senior author, who also identified the non-ostracod species, the junior author cooperating in the study of critical points in the field. The sections in the Fairview Mountain anticline were described by the senior author. The ostracods named in the sections were identified by Ulrich and Bassler.

[2] The formation receives its name from McKenzie station which is situated at the eastern end of the railroad cut.

thick just across the river in West Virginia. The *Whitfieldella marylandica* zone is found at the top of the Rochester formation, while the *Uncinulus obtusiplicatus* zone is 39 feet below the top of the McKenzie.

As a collecting ground the section is much inferior to those exposed at Cedar Cliff, Rose Hill, and Cumberland, due, in part, to the less weathered condition of the rocks at Pinto. It is, however, unequaled for its completeness.

Plate V shows the McKenzie formation exposed here with its nearly vertical strata. The beds are intricately folded and much faulted, making an accurate measurement of their thickness rather difficult. The throw of each fault has been calculated as accurately as possible and the measurements given are very nearly correct.

The section described below embraces the McKenzie, Rochester, and a large part of the Rose Hill formations. It begins at the base of the Bloomsburg member of the Wills Creek formation, in the cut west of the cement mill, and extends to the eastern end of the cut, east of the mill.[1]

WILLS CREEK FORMATION

Bloomsburg Member

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
Yellow, disintegrated limestone, *Cedar Cliff limestone*	376	0	..	..	..	..
Massive, greenish-gray sandstone	..	..	8	6	8	6
McKENZIE FORMATION						
Greenish-gray and brownish-yellow, thin-bedded sandstone transitional to Bloomsburg sandstone containing *Clidophorus nitidus*	367	6	2	6	241	6
Drab shale containing many indistinct worm borings	365	0	14	6	239	0
Dark arenaceous limestone and drab shale, limestone predominating. Fault at bottom	350	6	8	0	224	6

[1] The horizontal measurement begins at the top of the Keefer sandstone and extends along the railroad track. This section is continuous with the section of the Wills Creek and Tonoloway formations described on pages 114-126.

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
Drab shale and interbedded impure dark limestone, mostly shale. The lower beds contain *Lingula* sp., *Camarotœchia andrewsi, Uncinulus obtusiplicatus, Homœospira evax* var. *marylandica, Uncinulus obtusiplicatus* zone. A thrust fault in this unit has 1-foot throw......	342	6	25	0	216	6
Interbedded drab shale and dark impure limestone containing various species of *Euklœdenella* and *Dizygopleura*.........	322	0	4	0	191	6
Interbedded drab shale and dark impure limestone in about equal amounts, carrying *Tentaculites niagarensis*...........	313	0	8	0	187	6
Interbedded drab shale and some dark, impure limestone in beds from 1 to 3 inches, containing *Camarotœchia andrewsi, Clidophorus nitidus*. Ten feet below the top occurs *Buthotrephis gracilis* var. *intermedia, Whitfieldella marylandica. Ctenodonta subreniformis* is found at base....	..	..	23	0	179	6
Dark, calcareous shale bearing *Lingula* sp., *Homœospira evax* var. *marylandica, Clidophorus nitidus, Pterinea flintstonensis,* and *Hormatoma marylandica*..........	273	0	7	6	156	6
Drab shale and occasional limestone layers bearing *Clidophorus nitidus, Pterinea flintstonensis, Hormatoma marylandica*.	264	0	14	6	149	0
Thick-bedded, dark impure limestone......	..	..	1	6	134	6
Drab shale and some thin-bedded, dark, impure limestone bearing at top *Clidophorus nitidus* and *Hormatoma marylandica*	248	0	3	0	133	0
Thin-bedded, dark, impure limestone and some interbedded drab shale bearing *Lingula gracilis* and *Hormatoma marylandica*	..	..	5	0	130	0
Thin-bedded, dark, impure limestone and drab shale in about equal amounts. About 9 feet from top is a small fault with a heave of approximately 8 inches. This unit contains *Butrotrephis gracilis* var., *Lingula gracilis, Dalmanella ele-*						

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
gantula, Camarotœchia andrewsi, Clidophorus nitidus, Hormatoma marylandica, H. hopkinsi, Homœospira evax var. *marylandica, Pterinea flintstonensis*	..	..	44	0	125	0
Dull-black to drab shaly limestone resembling a cement rock. Fault at top of unit. The bottom of this unit was situated at the west end of spring before the fill was made. (West end of spring is at 173 feet of traverse)	182	0	6	0	81	0
Interbedded, dark, impure limestone and shale containing *Hormatoma marylandica* and *H. hopkinsi*	172	0	27	0	75	0
Interbedded shale and dark, impure limestone carrying in upper part *Clidophorus nitidus*	..	..	20	0	48	0
Concealed along railroad track by faulting.	117	0	5	0	28	0
Drab shale and interbedded dark limestone. Four feet above its base in center of a small anticline (72 feet west of top of Keefer sandstone) is a dark limestone interbedded with gray limestone which contains *Reticularia bicostata* and *Clidophorus nitidus*	117	0	8	6	23	0
Thick beds of limestone and interbedded shale. Three feet above base occurs numerous *Beyrichia moodyi*	..	..	5	0	14	6
Massive dark impure limestone and some interbedded shale. The limestone bears *Reticularia bicostata, R. bicostata* var. *marylandica, Beyrichia moodyi, Dizygopleura micula, Kuklœdenella longata,* and other species of *Euklœdenella*	..	..	5	6	9	6
Drab shale with some bands of dark limestone. This unit is badly crushed. Thickness estimated	62	0	1	6	4	0
Thick-bedded, dark limestone containing numerous elongated limestone pebbles of a different color. This bed forms a projecting ledge near top of cut	..	..	2	6	2	6
Total thickness of McKenzie formation					241	6

ROCHESTER FORMATION

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
Dark shale	54	0	1	3	39	0
Thick-bedded, dark, lenticular limestone and some interbedded dark shale. The limestone contains *Whitfieldella marylandica*, *Lingula* sp., *Dizygopleura pricei*, *D. gibba*, *D. intermedia* var. *antecedens*, *D. intermedia* var. *cornuta*. Thickness along track	..	..	4	6	37	9
Thick-bedded, dark lenticular limestone with some interbedded shale. *Whitfieldella marylandica* is very profuse 3 feet above base. *Tentaculites niagarensis* occurs near base. The base of this unit is repeated 43 feet west of the top of the Keefer sandstone by minor faulting. Thickness about	..	..	4	6	33	3
Dark-gray shale with thin beds of crystalline bluish-gray limestone. *Cornulites rosehillensis* and *Schuchertella elegans* occur about 18 feet above its base. *Dalmanites limulurus* is found abundantly in lower 10 feet of unit. This unit bears *Æchmina abnormalis*, *A. postica*, *A. spinosa*, *Beyrichia veronica*, *Dizygopleura symmetrica*, *Drepanellina clarki* abundant	29	0	19	0	28	9
Olive shale and bands of highly fossiliferous crystalline gray limestone containing *Stropheodonta corrugata*, *Homalonotus delphinocephalus*, *Drepanellina clarki*, *Æchmina spinosa*	..	..	2	6	9	9
Iron ore (*Roberts iron ore*) ..	..	..	0	6	7	3
Keefer Sandstone Member						
Hard, gray, fine-grained slightly calcareous sandstone	..	..	7	0	7	0
Total thickness of Rochester formation					39	0

ROSE HILL FORMATION

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
Greenish-gray and chocolate-colored shales and interbedded thin bands of sandstone. The shale is more deeply chocolate-colored about 44 feet from the bottom. In the upper 12 feet the sandstone is replaced in part by limestone bands. Toward the top occur *Cornulites rosehillensis*, *Stropheodonta* sp., *Schuchertella tenuis*, *Dalmanella elegantula*. Fourteen feet below the top of this unit occur *Chonetes novascoticus*, *Æchmina crassa*, *Plethobolbina typicalis*, *Mastigobolbina arguta*. Twenty feet below top occur *Chonetes novascoticus* and *Camarotœchia neglecta*. Base of this unit is 115 feet east of top of Keefer sandstone..........	..	..	100	0	552	2
Hackly, chocolate-colored shales showing spheroidal weathering. A few thin sandstone layers occur in upper part of the unit. Towards the bottom the sandstone beds are more numerous and the shales are lighter-colored. Base of this unit is in center of an anticline 190 feet east of the top of the Keefer sandstone. The section is repeated east of this unit......	..	..	48	0	452	2
Concealed in rear of cement mill. Thickness estimated to be about.............	..	..	150	0	404	2
The section is continued east of the cement mill. Olive to gray shale with a few thin sandstone lenses	..	..	16	0	254	2
Sandstone with *Cœlospira hemispherica*, *Calymene cresapensis*, and many ostracods	..	..	0	6	238	2
Gray, somewhat mottled shale containing many *Buthotrephis gracilis* var. *intermedia*	..	..	11	6	237	5
Sandstone layer with many *Tentaculites* sp., *Calymene* sp., ostracods and crinoid stems	..	..	0	4	226	2
Gray shale	..	..	3	0	225	10

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
Sandstone with a great many *Tentaculites minutus*	..	..	0	4	222	10
Gray shale with a few interbedded thin sandstone layers	..	..	20	0	222	6
Gray shale bearing *Cœlospira hemispherica* and *Buthotrephis gracilis* var., *intermedia* which is more abundant toward the bottom of unit	..	..	9	0	212	6
Hackly gray shale with very few sandstone lenses	..	..	8	0	193	6
Red ferruginous sandstone and interbedded shales. The sandstone contains so much hematite as to approach a low-grade iron ore, the *Cresaptown iron sandstone*, consisting of the following beds:	..	..	30	6	185	6
Ferruginous sandstone	..	..	0	8	..	..
Gray sandstone	..	..	0	6	..	..
Shale	..	..	0	8	..	..
Interbedded ferruginous sandstone and shale	..	..	1	6	..	..
Massive ferruginous sandstone	..	..	4	0	..	..
Shaly sandstone and thin beds of ferruginous sandstone	..	..	1	2	..	..
Ferruginous sandstone showing cross-bedding and clay balls at top	..	..	0	6	..	..
Ferruginous sandstone, many clay balls and lenses	..	..	1	6	..	..
Interbedded shale and ferruginous sandstone	..	..	1	0	..	..
Ferruginous sandstone, the upper part highly oölitic, the lower part bearing some plant remains. Its upper surface is ripple-marked, the wave crests being about 1 foot apart with smaller intervening crests. The troughs between the crests are not quite filled with shale	..	..	1	0	..	..
Massive beds of ferruginous sandstone	..	..	2	0	..	..
Shale and ferruginous sandstone	..	..	1	2	..	..
Massive bed of ferruginous sandstone containing *Stropheodonta* sp., *Meristina* sp., *Orthoceras bassleri*	..	..	6	0	..	..

	Horizontal distance from top of Keefer sandstone to top of beds		Thickness			
			Beds		Total	
	Feet	Inches	Feet	Inches	Feet	Inches
Shale and thin ferruginous sandstone	..	..	0	9	..	..
Ferruginous sandstone	..	..	1	8	..	..
Gray shale	..	..	0	8	..	..
Gray shaly sandstone	..	..	0	6	..	..
Fissile gray shale	..	..	1	6	..	..
Ferruginous sandstone	..	..	1	8	..	..
Shale	..	..	0	2	..	..
Ferruginous sandstone in two beds	..	..	1	3	..	..
Shale	..	..	0	3	..	..
Ferruginous sandstone	..	..	0	5	..	..
Fissile gray shale with a few thin beds of sandstone	..	..	150	0	155	0
Concealed to base of the formation, estimated to be about	..	..	140	0	140	0
Approximate thickness of the Rose Hill formation					552	0

Ostraeods are very numerous in the McKenzie formation at Pinto and collections taken from nearly every part show most of the following species: *Klœdenella nitida, Dizygopleura halli, D. intermedia, D. perrugosa, Beyrichia moodyi.*

II. Section along Baltimore and Ohio Railroad, 1½ miles northeast of Pinto

This section embraces 209 feet of the middle and lower strata of the Rose Hill formation and supplements that seen at Pinto. The section here described represents two exposures; one giving the portion of the Rose Hill formation between the Tuscarora and the Cresaptown iron sandstone, the other beginning at the base of the Cresaptown sandstone and extending upwards in the strata.

The first of these exposures is seen where the Baltimore and Ohio Railroad cuts through the eastern of two sharp anticlinal folds which are found between Pinto and Brady, its base being the top of the Tuscarora sandstone. The second begins a little to the northwest of the second sharp fold and continues with low-dipping strata, here and there concealed in part, nearly to Brady station.

ROSE HILL FORMATION

	Beds Feet	Beds Inches	Total Feet	Total Inches
Concealed.				
Shales and interstratified, grayish to brown sandstones with gentle dip, finely exposed along the railroad. The color and character of the shales of some beds seem to change considerably with small difference in location and exposure. Shales barren. The sandstones carry *Camarotœchia neglecta*, *Tentaculites minutus*, and *Calymene* sp.	25±	0	209	6
Red ferruginous sandstone and interbedded shale. *The Cresaptown iron sandstone* comprising the following beds:				
Red fossiliferous sandstone, massive at bottom. Shale partings toward top	13	0	184	6
Greenish-gray, calcareous shale	6	0	171	6
Red ferruginous sandstone	4	6	165	6
Olive to greenish-gray, arenaceous shales with sandstone bands which become harder and more numerous toward the bottom. Sparingly fossiliferous. Rather poorly exposed. This unit bears *Camarotœchia neglecta*, *Cœlospira hemispherica*, *Tentaculites minutus*, *Mastigobolbina lata*	161	0	161	0
Total thickness of Rose Hill formation exposed.			209	6

TUSCARORA FORMATION

Massive white sandstone.

III. Section at Cedar Cliff

An excellent section of the upper 170 feet of the McKenzie formation is seen in the cut of the Baltimore and Ohio Railroad at Cedar Cliff, Maryland, 4 miles southwest of Cumberland. The strata exposed at this place are almost identical in character with the corresponding beds at Pinto. They are, however, more weathered and the fossils are much more easily obtained.

In the eastern end of the cut a reversed fault, having a vertical displacement of about 20 feet, intersects the rocks lying near the McKenzie-Wills Creek contact. Forty feet below the top of the McKenzie formation occurs a great abundance of *Uncinulus obtusiplicatus*, a species characteristic of this portion of the formation throughout the greater part of the Maryland area. Below this is a zone abounding in *Camarotœchia andrewsi.* The section here measured is as follows:

	Thickness			
	Beds		Total	
WILLS CREEK FORMATION *Bloomsburg Member*	Feet	Inches	Feet	Inches
Dark-brown sandstone	2	0	22	6
Calcareous shale	1	6	20	6
Cedar Cliff limestone consisting of				
Thin-bedded limestone and shale	1	6	19	0
Rather massive, dark-gray limestone	5	0	17	6
Yellow, disintegrated, ferruginous, thin-bedded limestone and shale. *Leperditia* sp	1	6	12	6
Platy, ferruginous and calcareous sandstone. *Leperditia* sp.	1	0	11	0
Yellowish, sandy limestone, toward base many nodules of limy matter	2	6	10	0
Brown sandstone	2	6	7	6
Argillaceous sandstone with shale partings	5	0	5	0
Thickness of Bloomsburg member			22	6
MCKENZIE FORMATION				
Dark, mottled, arenaceous shale	11	0	295	0
Argillaceous sandstone with fucoid markings	1	0	284	0
Dark-gray shale with some interbedded sandstone in the upper part containing, 6 inches below the base, *Clidophorus nitidus*, *Hormatoma* sp., and *Orthoceras mackenzicum*	2	0	283	0
Interbedded shale and thin-bedded limestone bearing, 3 feet 8 inches above the base, *Ctenodonta subreniformis* common	11	8	281	0
Dark, fossiliferous shale containing *Spirifer mackenzicus* and *Clidophorus nitidus*, both common	2	4	269	4
Interbedded shale and thin-bedded limestone	6	4	267	0
Calcareous shale with thin bands of limestone. In the upper 3 feet are found *Dalmanella elegantula*, *Camarotœchia andrewsi*, *Uncinulus obtusiplicatus*, *Cuneamya ulrichi*, and *Poleumita mackenzica*	6	2	260	8
Interbedded limestone and calcareous shale. Thicker beds of limestone at the top and bottom of this unit. In the upper 2 feet are found *Lingula clarki*, *Uncinulus obtusiplicatus*, and *Poleumita mackenzica*. From 4 to 6 feet below the top occur *Lingula clarki*, *Dalmanella elegantula* in great abundance, *Camarotœchia andrewsi* in great abundance, *Uncinulus obtusiplicatus* in great profusion, and *Cuneamya ulrichi*. From 7 to 12 feet below the top are found				

VIEW SHOWING LOVERS LEAP IN THE NARROWS OF WILLS CREEK NEAR CUMBERLAND.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Dalmanella elegantula. Uncinulus obtusiplicatus. Cuneamya ulrichi, Clidophorus nitidus. Hormatoma marylandica, Polcumita mackenzica, Diaphorostoma niagarense, and *Tentaculites niagarensis* common. In basal limestone occur *Bollia immersa, B. nitidula, Zygobcyrichia incipiens, Z. ventricornis, Klœdenia normalis, Bythocypris pergracilis*	18	6	254	6
Calcareous shale with some thin bands of limestone. *Favosites marylandicus* common, *Dalmanella elegantula,* and *Tentaculites niagarensis* var. *cumberlandiæ* common occur at 1, 3 and 6 feet below the top, respectively	10	0	236	0
Grayish-green shale and interbedded limestone. From 2 to 6 feet below the top occur *Orbiculoidea clarki* abundant, *Camarotœchia andrewsi, Homœospira evax* var. *marylandica* abundant, and *Pterinea flintstonensis.* From 9 to 13 feet *Pterinea flintstonensis* is abundant. Sixteen feet below the top are found *Favosites marylandicus. Camarotœchia andrewsi,* and *Orthoceras mackenzicum. Clidophorus nitidus* is common from 17 to 23 feet below the top of this unit. Twenty-five feet below the top it becomes abundant. *Lingula subtruncata* occurs 26 feet below the top, while 28 to 32 feet below the top are found *Camarotœchia andrewsi, Clidophorus nitidus* common, and *Hormatoma hopkinsi.* Thirty-six feet below the top occurs *Hormatoma marylandica*	42	0	226	0
Dark-blue limestone with thin shale partings. Four feet below the top occur *Hormatoma hopkinsi* abundant, and *Orthoceras mackenzicum. Clidophorus nitidus* is found from 5 to 8 feet below the top. Nine to 10 feet below the top occur *Hormatoma hopkinsi* common, *Clidophorus nitidus* in abundance and *Pterinea flintstonensis.* From 14 to 16 feet below the top are found *Favosites niagarensis. Orbiculoidea clarki, Homœospira evax* var. *marylandica* common, and *Clidophorus nitidus.* Twenty-four feet below the top occur *Orbiculoidea clarki* and *Orthoceras mackenzicum.* Twenty-nine feet below the top occur *Orbiculoidea clarki, Dalmanella elegantula,* numerous *Homœospira evax* var. *marylandica* and *Clidophorus nitidus*	54	0	184	0
Concealed. Thickness about	130	0	130	0
Total thickness of McKenzie formation about			295	0

IV. Section at Rose Hill South of Cumberland

An excellent section of the lower part of the McKenzie formation, the Rochester formation, and the upper beds of the Rose Hill formation is seen in the cut of the Baltimore and Ohio Railroad at the southern end of Rose Hill, $1\frac{3}{4}$ miles southwest of Cumberland.[1] This is one of the finest localities in the state for the examination of the Rochester formation and its contact with the immediately adjoining strata and affords an excellent collecting ground for the fossils found in them. It is complicated by faulting, rendering precise measurement of its thickness difficult. A fault seen 46 feet east of the top of the Keefer sandstone causes the lower 20 feet of the overlying beds to be repeated. The measurements are as follows:

McKENZIE FORMATION

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Dark-blue to grayish-blue, impure limestone with shale partings. *Orthoceras mackenzicum* and *Favosites* cf. *niagarensis* are found especially in the upper 20 feet. Center of syncline 5 feet above base of unit.........	70	0	109	0
Limestone, dark and impure........................	2	0	39	0
Black, calcareous shale carrying many ostracods......	2	0	37	0
Thin-bedded limestone and shale in about equal amounts	11	0	35	0
Drab shale	2	0	24	0
Thick-bedded limestone with thin shale partings......	11	0	22	0
Interbedded limestone and shale in thin beds.........	5	6	11	0
Thick-bedded massive limestone and shale in thin beds	4	0	7	0
Drab shale	1	3	1	6
Thin limestone band containing 6 inches below top *Klœdenella nitida, Dizygopleura halli, D. intermedia D. perrugosa, Beyrichia moodyi*..................	0	3	20	6
Thickness of McKenzie formation described....			109	0

ROCHESTER FORMATION

Thick-bedded limestone bearing *Whitfieldella marylandica*	3	0	64	11
Dark-gray shale with thin limestone beds. About this horizon is *Strophcodonta corrugata* var. *pleuristriata*	6	0	61	11
Interbedded blue limestone and drab shale. Two feet above base occurs *Drepanellina ventralis*..........	7	10	55	11

[1] The Rose Hill formation receives its name from the section at the northern end of Rose Hill in Cumberland, described on page 68.

	Thickness: Beds, Feet	Beds, Inches	Total, Feet	Total, Inches
Dark, bluish-gray fine-grained limestone containing many light-colored lenses of limestone forming a limestone conglomerate	1	0	48	1
Drab shale above. At base a bed of black limestone 8 inches thick with light-colored spots in it in many places, containing *Favosites* sp., *Whitfieldella marylandica, Æchmina spinosa, A. ventralis, Drepanellina ventralis.* The base of this unit is 123 feet east of the top of the Keefer sandstone..................	1	2	47	1
Drab shale. A thin band of limestone in the middle abounds in *Whitfieldella marylandica*, bears also *Schuchertella elegans, Tentaculites niagarensis*....	0	9	45	11
Limestone bed made up in large part of *Whitfieldella marylandica* but contains also *Schuchertella subplana, Drepanellina clarki, Dizygopleura asymmetrica, Æchmina abnormalis, A. spinosa, Aparchites alleghaniensis, Beyrichia veronica.* The base of this bed is 103 feet east of the top of the Keefer sandstone	0	11	45	2
Drab shale bearing *Pholidops squamiformis.* At base is a thin limestone band containing *Schuchertella subplana, Drepanellina clarki, Dizygopleura asymmetrica, D. proutyi, Æchmina abnormalis, A. spinosa, Aparchites alleghaniensis*	1	4	44	3
Drab shale above. Thin gray limestone at base contains *Schuchertella elegans* common, *S. subplana, Whitfieldella marylandica. Drepanellina clarki, Dizygopleura asymmetrica, D. proutyi, Æchmina abnormis, A. spinosa, Aparchites alleghaniensis, Beyrichia veronica*	0	9	42	11
Drab shale above. At base a band of limestone contains *Cornulites concavus, Pholidops squamiformis, Schuchertella elegans, Dalmanites elegantula, Camarotœchia neglecta, Whitfieldella marylandica, Tentaculites niagarensis*	1	1	42	2
Drab shale above bearing *Reticularia bicostata.* At base a platy limestone contains *Stropheodonta corrugata* var. *pleuristriata, S. deflecta, Drepanellina clarki, Dizygopleura symmetrica, D. proutyi, Æchmina abnormis, A. spinosa*......................	1	1	41	1
Fissile, dark-gray shale carrying *Whitfieldella marylandica, Pterinea emacerata. Tentaculites niagarensis.* A thin band of limestone at base contains *Cornulites rosehillensis, Stropheodonta corrugata, Dalmanella elegantula, Camarotœchia neglecta, Whit-*				

	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
fieldella marylandica, Homalonotus delphinocephalus, Dalmanites limulurus, Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis, A. spinosa, Beyrichia veronica	2	1	40	0
Interbedded drab shale and dark-gray limestone. A band of limestone at the top contains *Cornulites concavus, Pholidops squamiformis, Stropheodonta corrugata, Spirifer* sp., *Reticularia bicostata, Whitfieldella marylandica, Homalonotus lobatus.* A thin band of limestone at base contains *Dalmanella elegantula, Whitfieldella marylandica* very abundant, *Dalmanites limulurus*	1	8	37	0
Drab shale bearing *Camarotœchia neglecta.* A band of limestone at base contains *Cornulites rosehillensis, Stropheodonta corrugata, Camarotœchia neglecta, Atrypa reticularia, Whitfieldella marylandica, Tentaculites niagarensis* var. *cumberlandiæ, Homalonotus delphinocephalus, H. lobatus, Dalmanites limulurus, Drepanellina clarki, Dizygopleura symmetrica, D. proutyi*	1	4	36	3
Drab shale with *Pterinea emacerata.* At base a grayish-blue crystalline limestone forms a projecting ledge. The limestone contains *Stropheodonta corrugata* var. *pleuristriata, Pholidops squamiformis, Camarotœchia neglecta, Diaphorostoma niagarensis, Encrinurus ornatus, Honolonotus delphinocephalus, H. lobatus, Drepanellina clarki, Dizygopleura symmetrica, D. proutyi*	2	0	34	11
Drab shale with bands of crystalline gray limestone. Limestone lenses contain in upper part *Stropheodonta corrugata, S. deflecta, Dalmanella elegantula, Camarotœchia neglecta, Reticularia bicostata* var. *marylandica, Dalmanites limulurus, Drepanellina clarki, Dizygopleura symmetrica, D. asymmetrica, Æchmina abnormis, A. spinosa.* One foot above base occurs *Conularia niagarensis.* A thin band of limestone at base contains *Stropheodonta corrugata, Leptæna rhomboidalis, Dalmanella elegantula, Camarotœchia neglecta, Conularia niagarensis*...........	5	0	32	11
Dark-gray fissile shale bearing *Reticularia bicostata.* Impure platy limestone at base contains *Stropheodonta corrugata, S. corrugata* var. *pleuristriata, S. deflecta, Camarotœchia neglecta, Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis, A. spinosa*..............................	2	0	27	11

	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Dark-gray fissile shale. At base is a thin limestone band containing *Dalmanites limulurus*............	1	4	25	11
Dark-gray fissile shale bearing *Cornulites concavus, C. rosehillensis, Leptæna rhomboidalis, Schuchertella subplana, Atrypa reticularis, Spirifer crispus, Bucanella trilobata, Diaphorostoma niagarense*....	4	11	24	7
Interbedded, thin gray limestone and fissile gray shale bearing *Stropheodonta corrugata, Dalmanella elegantula, Platyceras unguiforme, Diophorestoma niagarense, Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis*.........................	1	4	21	3
Dark-gray, fissile argillaceous shale with thin bands of crystalline limestone. A band 5 feet above base contains *Stropheodonta corrugata, Leptæna rhomboidalis, Schuchertella tenuis, Rhipidomella hybrida, Atrypa reticularis, Spirifer crispus, Pterinea emacerata, Hormatoma* sp., *Poleumita* sp., *Platyceras unguiforme, Diphorestoma niagarense, Homalonotus lobatus*. A band 3 feet above the base contains *Stropheodonta corrugata, Dalmanella elegantula, Camarotœchia neglecta, Uncinulus stricklandi, Homalonotus delphinocephalus, Dalmanites limulurus, Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis, A. spinosa*.............................	7	0	19	11
Gray sandstone stained red.........................	0	6	12	11
Fossiliferous oölitic iron ore. The *Roberts iron ore*..	0	8	12	5
Keefer Sandstone Member				
Shaly sandstone, brownish above base.................	1	11	11	9
Massive gray sandstone with many cavities ½ inch in diameter and many small tubular openings.........	8	0	9	10
Shaly sandstone	1	10	1	10
Thickness of Rochester formation............			64	11
ROSE HILL FORMATION				
Interbedded shale and calcareous sandstone..........	3	0	..	..
Fissile shale	5	0	..	..
Light-gray limestone containing *Chonetes novascoticus, Cœlospira sulcata* abundant.....................	0	6	..	..

	Thickness: Beds, Feet	Thickness: Beds, Inches	Thickness: Total, Feet	Thickness: Total, Inches
Olive to brown shale interbedded with thin, slightly calcareous sandstone. The upper 30 feet of this unit are seen in the railroad cut, the underlying beds are poorly exposed west of the cut. This unit contains *Atrypa reticularis*, *Cœlospira sulcata*, and *Bucanella trilobata*	90	0	..	..
Thickness of Rose Hill formation exposed......			98	6

The thickness assigned the Rochester formation is much greater in this section than elsewhere in Maryland. The McKenzie-Rochester contact is not marked clearly by lithological change but is determined by change in the ostracod faunas.

V. Section at Cumberland

The best and most carefully studied section of the Rose Hill formation in Maryland is at the north end of Rose Hill, Cumberland, from which locality the formation receives its name. The section is seen along the Western Maryland Railway and in its immediate vicinity east of the "Narrows," the gorge cut by Wills Creek through Wills Mountain. This locality affords a nearly continuous exposure of the strata between the top of the Tuscarora formation and the *Whitfieldella marylandica* zone at the top of the Rochester formation. About 100 feet of the immediately overlying beds of the McKenzie formation are also poorly exposed on Camp Hill along the top of the cliff immediately overlooking Wills Creek. The McKenzie-Wills Creek contact is, however, finely shown west of the old cement quarry.

A shale having a faint reddish tone is seen 313 feet east of the Keefer sandstone and appears to occupy approximately the position of the red bed so prominent in the middle of the McKenzie formation east of Hancock.

The contact of the Rose Hill and the Tuscarora formations is admirably exposed, showing that the formations are connected, locally, by transitional beds.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
WILLS CREEK FORMATION				
Bloomsburg Member				
The section is exposed in cliff east of cement quarry.				
Compact standstone, upper 8 inches red, lower bed greenish	3	6	3	6
McKENZIE FORMATION [1]				
Thin-bedded argillaceous sandstone; greenish above, dark below with numerous worm borings parallel to bedding	6	0	294	7
Dark shale, fossiliferous above, worm borings below	4	0	288	7
Fissile drab shale with thin bands of limestone above, concealed below. The upper 50 feet of this unit contains *Dizygopleura acuminata, D. swartzi, D. carinata, Euklœdenella punctillosa.* The middle part of the unit bears *Æchmina depressa, Klœdenella nitida, K. scapha-brevicula, K. immersa, Dizygopleura perrugosa, Euklœdenella sinuata proclivis, Bythocypris obesa*	175	0	284	7
The section is continued in the bluff overlooking the Western Maryland Railway.				
Shale, faint reddish tone, exposed 313 feet east of Keefer sandstone. Thickness about	5	0	109	7
Shale with numerous thin beds of limestone. The upper part of this unit abounds in *Hormatoma marylandica, H. hopkinsi, Orthoceras* sp. About 25 feet above the base of this unit occur *Dizygopleura subdivisa, D. intermedia.* Thickness about	100	0	104	7
Dark limestone with a bed of shale 11 inches thick in its middle	2	9	4	7
Drab shale. At its base is a bed of dark-gray limestone 9 inches thick with many calcite veins. Surface weathering light gray, in part a limestone conglomerate	1	10	1	10
Total thickness of McKenzie formation			294	7

[1] The distance between the top of the Keefer sandstone and the base of the Cedar Cliff limestone lens in the Bloomsburg red sandstone is 640 feet S. 61° E. (measured by tape). The average dip of the rocks between these points is 32° 18′ as a result of 31 observations. This gives a thickness of 294 feet for the McKenzie formation.

ROCHESTER FORMATION

	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Drab, fissile shale. At its base is a band of dark-colored, fine-grained limestone with many calcite veins and many *Whitfieldella marylandica*	2	0	46	1
Drab to olive, argillaceous shale with numerous *Whitfieldella marylandica.* At its base is a bed of limestone containing *Whitfieldella marylandica* and ostracods	1	2	44	1
Olive to drab shale	9	0	42	11
Grayish-blue limestone containing *Pholidops squamiformis, Stropheodonta corrugata, Camarotœchia neglecta, Whitfieldella marylandica, Dalmanites limulurus, Æchmina spinosa, A. abnormis, A. postica, A. cumberlandiæ, Dizygopleura proutyi, D. symmetrica, D. asymmetrica, Aparchites alleghaniensis, Beyrichia veronica, Primitia resseri, Drepanellina clarki, D. modesta*	0	6	33	11
Drab shale containing *Camarotœchia neglecta*	2	0	33	5
Bluish-gray limestone bearing *Cornulites* cf. *concavus, Stropheodonta corrugata, Camarotœchia neglecta, Dalmanella elegantula, Whitfieldella marylandica, Homalonotus lobatus*	0	8	31	5
Drab shale. A bed of grayish-blue medium-grained limestone bears *Stropheodonta corrugata, Schuchertella elegans, Dalmanella elegantula, Camarotœchia neglecta, Atrypa reticularis, Conularia* sp., *Homalonotus delphinocephalus, Dalmanites limulurus*	1	0	30	9
Drab shale. At its base is a band of shaly sandstone carrying *Stropheodonta corrugata, Leptæna rhomboidalis, Camarotœchia neglecta* very abundant, *Homalonotus delphinocephalus, H. lobatus*	1	2	29	9
Drab to olive shale	8	0	28	7
Crystalline gray limestone containing *Cornulites concavus, Stropheodonta corrugata, S. deflecta, Leptæna rhomboidalis, Dalmanella elegantula, Rhipidomella hybrida, Camarotœchia neglecta, Atrypa reticularis, Reticularia bicostata, Platyceras niagarense, P. unguiforme, Diaphorostoma niagarense, Homalonotus delphinocephalus, H. lobatus, Dalmanites limulurus.*	0	8	20	7
Olive to drab shale	4	0	19	11
Crystalline gray limestone, bearing *Favosites favosus, Cornulites rosehillensis, Stropheodonta corrugata, Dalmanella elegantula, Rhipidomella hybrida, Camarotœchia neglecta, Spirifer crispus, Platyceras unguiforme, Liopteria subplana, Diophorostoma niagarense, Stylolina* sp., *Coleolus* sp., *Homalonotus delphinocephalus, Dalmanites limulurus*	0	5	15	11

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Olive to drab shale carrying *Uncinulus stricklandi*, *Sphyrodoceras* cf. *desplainense*....................	4	0	15	6
Iron ore. *Roberts iron ore*..........................	0	6	11	6
Keefer Sandstone Member				
Massive sandstone. Upper 2 feet very calcareous, lower foot iron-stained and carrying the following poorly-preserved fossils: *Camarotœchia neglecta*, *Liocalymmene clintoni*, *Stropheodonta* sp., crinoid stems.....	11	0	11	0
Total thickness of Rochester formation.........			46	1

ROSE HILL FORMATION

The section is continued along the road leading southwest from the top of the bluff. The traverse begins at the base of the Keefer sandstone about 700 feet southwest of the railroad and extends 681 feet towards the west. Average strike and dip N. 34° E. 37° E.

Traverse S. 83° W. 200 feet

	Feet	Inches	Feet	Inches
Thin-bedded olive to drab argillaceous shale, with occasional thin sandstone beds, carrying near base *Dalmanella elegantula*, *Atrypa reticularis*, *Cœlospira sulcata*, *Tentaculites minutus*, *Liocalymmene clintoni*. *Mastigobolbina typus*. *Plethobolbina cornigera*, *P. typicalis*, *Dizygopleura symmetrica*. *Bonnemaia celsa*	20	0	552	0
Purplish to reddish, thin-bedded argillaceous shale....	6	0	532	3
Olive to light-red argillaceous shale, carrying *Tentaculites minutus*	2	0	526	0
Thin-bedded drab argillaceous shale with some reddish to purple layers and occasional beds of sandstone, carrying 10 feet below the top many *Atrypa reticularis*. Fifteen feet below the top *Chonetes novascoticus;* 18 feet below the top *Orthoceras* sp.; 21 feet below top *Dalmanella elegantula*, *Cœlospira sulcata*, *Liacalymmene clintoni;* 38 feet below the top *Cœlospira hemispherica*	42	0	524	0
Olive to purple shale and a few thin sandstone layers containing many *Cœlospira sulcata*. This and the next unit constitute the *Bonnemaia rudis* zone containing *Bonnemaia obliqua*. *B. pulchella*, *B. longa*, *Mastigobolbina virginica*	12	0	482	0

Traverse S. W.[1]	Thickness: Beds, Feet	Beds, Inches	Total, Feet	Total, Inches
Reddish, fissile shale	8	0	470	0
Thin-bedded, argillaceous shale with occasional thin beds of sandstone containing *Buthotrephis* cf. *gracilis* var. *Zygosella postica*	112	0	462	0
Concealed	5	0	350	0
The section is continued on the bluff south of the railroad and east of the ravine. The units were measured directly.				
Rusty to gray argillaceous shale bearing *Camarotœchia neglecta*	1	0	345	0
Concealed	12	0	344	0
Rusty-gray to olive, argillaceous shale bearing in places numerous *Buthotrephis* sp. The base of this unit is at the foot of the hill on the east side of the valley, near the railroad	15	0	332	0
Concealed in valley, probably shale	20	0	317	0
The section is continued in a small cross valley a few hundred feet southwest of the railroad track.				
Rusty-gray to brown, argillaceous shale with some sandstone bands; not well exposed. The top of this exposure is east of the road and opposite a path leading up hill to an old powder house	21	0	297	0
Argillaceous shale becoming dark-colored and brown toward the top, with some ferruginous sandstone layers, 1 to 2 inches thick, bearing *Camarotœchia neglecta, Tentaculites minutus,* and numerous ostracods. The beds are not well exposed here but are seen in path leading up hill southwest of the powder house	20	0	276	0
Rusty-gray to olive argillaceous shale with thin beds of sandstone near top, which bear *Tentaculites minutus, Calymmene cresapensis* and many ostracods	11	0	256	0
Mottled shale containing *Buthotrephis* sp. At its base is a sandstone containing *Camarotœchia neglecta, Calymmene cresapensis*	18	0	245	0
Rusty-gray to olive shales with two conspicuous sandstone beds about 6 inches thick, one 8 feet from top and one 4 feet from bottom. The shale contains fewer specimens of Buthotrephis than the beds be-				

[1] Traverse S. 73° W. from 200 to 336
S. 63° W. from 336 to 491
S. 55° W. from 491 to 581
S. 49° W. from 581 to 681, elevation at end 7 feet below point of beginning.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
low. The sandstone at the top bears *Chonetes novascoticus*, *Tentaculites minutus*, *Calymmene* sp., and a very striated *Conchidium*?. The lower sandstone layer contains the following fossils: *Butrotrephis* cf. *gracilis* var., *Chonetes* sp., *C. novascoticus*, *Camarotœchia neglecta*, *Cœlospira hemispherica*, *Tentaculites minutus*, *Calymmene cresapensis*, *Homalonotus delphinocephalus*, and many ostracods. About 3 feet from bottom occurs a thin layer of shale which contains numerous *Cœlospira hemispherica* and *Calymmene blumenbachii* var. *macrocephalus*..	23	0	226	9
Dark, fissile, rusty and knotty arenaceous shale bearing many plant remains. At its base is a sandstone lens carrying *Buthotrephis gracilis*, *Calymmene* cf. *cresapensis*	8	6	203	9
Fissile, argillaceous rusty shale with two sandstone layers near center. Upper sandstone contains *Camarotœchia neglecta*, *Calymmene* sp., *Mastigobolbina lata*	17	0	195	3
The section is continued along the Western Maryland Railway at the east end of the gap.				
Red iron sandstone consisting of red ferruginous sandstone and interbedded shale, the latter 4 inches thick. The sandstone contains so much hematite as to approach a low-grade oölitic iron ore. *Cresaptown iron sandstone*	10	4	178	3
Argillaceous shale bearing *Camarotœchia neglecta* crinoid stems, *Mastigobolbina lata*, *Zygosella brevis*, *Zygobolba arcta*, *Z. bimuralis*, *Zygobolbina conradi*, *Z. conradi latimarginata*.........................	6	0	167	11
Arenaceous shale with heavy lenses of quartzitic sandstone containing *Camarotœchia neglecta*, *Orthoceras* sp.	6	0	161	11
Slightly arenaceous, rusty shale weathering into small rectangular fragments, as a rule thin-bedded and fissile with an occasional thin sandstone layer. Eleven feet below the top of this unit occurs *Nuculites* sp., 20 feet below top *Camarotœchia neglecta*, *Cœlospira hemispherica*, *Mastigobolbina lata*, *M. vanuxemi*, *M. clarkei*, *Chilobolbina punctata bicornis*, *C. billingsi*, *Zygobolbina conradi*, *Z. conradi latimarginata*. The rocks under the southeast leg of water tank are 38 feet stratigraphically below the top of this unit where occurs *Ctenodonta willsi*......	98	0	155	11

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Arenaceous rusty and hackly shale, a band of sandstone at its base. Near top of this unit are found *Aparchites variolatus, Zygobolba minima, Beyrichia emaciata, Plethobolbina cribraria*..................	4	4	57	11
Fissile shale mottled with plant remains..............	1	0	53	7
Sandstone somewhat ferruginous and having irregular surface	3	0	52	7
Shaly sandstone	2	0	49	7
Hard sandstone with shale partings.................	1	6	47	7
Hackly, rusty, greenish shale........................	6	6	46	1
Grayish to dark-green sandstone....................	2	2	39	7
Argillaceous shale, dark-green and somewhat rusty above. Gray sandstone below....................	1	11	37	5
Argillaceous shale above; dark, fine-grained sandstone below	1	11	35	6
Arenaceous shale with thin sandstone layers with a prominent, dark-green sandstone 6 inches thick at base	16	6	33	7
Argillaceous shale and some thin sandstone bands having a fossil that resembles Caudagalli. The surfaces of the sandstone beds have irregularly-winding, tubular prominences resembling worm borings.....	5	0	17	1
Argillaceous sandstone and some interbedded sandy shale. Some of the lower beds of sandstone contain many clay balls	3	10	12	1
Thin-bedded, reddish sandstone with a few clay balls..	4	0	8	3
Arenaceous shale with many black carbonaceous bands resembling plant stems..........................	0	10	4	3
Argillaceous sandstone, stained yellow..............	1	1	3	5
Interbedded shale and thin sandstone layers..........	2	4	2	4
Total thickness of the Rose Hill formation......			552	0

TUSCARORA FORMATION

Hard sandstone penetrated by numerous rusty small tubes	5	4	38	0
Rusty sandstone with many lenses of clay. A shale layer contains *Camarotœchia neglecta*..............	0	8	32	8
Hard, heavy-bedded sandstone........................	3	0	32	0
Hard sandstone and thin interbedded layers of sandy shale, 1 to 3 feet thick containing a few worm borings and some clay balls............................	9	0	29	0
Massive, white sandstone bearing *Arthrophycus alleghenienis*	20	0	20	0

B. Sections in Evitts Mountain Anticline

VI. Sections near the Six-Mile House

Three excellent, partial sections of the McKenzie, Rochester, and Rose Hill formations are seen in the vicinity of the Six-Mile House, a hotel located on the National Road, six miles east of Cumberland. The combined exposures give a nearly complete section of the McKenzie, Rochester, and the upper and middle beds of the Rose Hill formations.

A. Section of Upper Part of McKenzie Formation

A fine exposure of the upper part of the McKenzie formation is seen upon a county road leading south from the National Road about ½ mile west of the Six-Mile House. The section described is situated about ½ mile south of the National Road. It is unfortunately complicated by folds so that measurements are difficult and it is probable that the thicknesses given below are excessive. The locality is of interest because of the marked development of the Hormatoma zone, certain of the beds containing such a profusion of gastropods of this genus as to form a veritable coquina.

WILLS CREEK FORMATION *Bloomsburg Member*	Horizontal distance from beginning to bottom of beds Feet	Thickness Beds Feet	 Total Feet
Green sandstone, stained brown containing *Leperditia alta*	..	2.4	9.0
Red, arenaceous shale	..	3.0	6.6
Massive red sandstone	..	3.6	3.6
Thickness of Bloomsburg member described			9.0
McKENZIE FORMATION Traverse N. 33° W.			
Approximate altitude of beginning of section 1080 feet A. T. on topographic map.			
Thick-bedded arenaceous shale, N. 73° E. 70° E	16.0	4.5	300.4
Fissile, green, somewhat arenaceous shale, its lower portion more compact, N. 80° E. 7° E	47.0	7.8	295.9
Concealed	129.0	19.0	288.1
Fissile green shale, partly concealed. N. 80° E. 6° E	142.2	2.7	291.1
Fissile gray shale, N. 55° E. 6° E. At top occurs a thin bed of dark-blue limestone containing *Camarotœchia andrewsi*, *Homœspira evax var. marylandica*, *Klœdenella nitida*, *Dizygopleura halli*, *D. intermedia*, *D. perrugosa*, *Beyrichia moodyi*	108.2	10.1	266.4

Traverse N. 86° W. Altitude of turn 1058 A. T.	Horizontal distance from beginning to bottom of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed. Some fissile gray shale, N. 67° E. 10° E..	242.2	11.0	256.3
Fissile shale, N. 20° E. 10° E. At top occurs a blue fossiliferous limestone 8 inches thick containing numerous *Camarotœchia andrewsi*	258.2	3.4	245.3
Fissile gray shale, N. 57° E. 6° E. and N. 35° E. 10° E. At top occurs a thin bed of limestone containing *Klœdenella nitida, Dizygopleura halli, D. intermedia, D. perrugosa, Beyrichia moodyi*	265.2	1.2	241.9
Gray fissile shale, N. 30° E. 10° E. At top occurs a thin limestone containing *Pterinea flintstonensis*	270.7	1.0	240.7
Fissile shale. At top is a thin band of limestone containing *Homœospira evax* var. *marylandica*	272.2	0.7	239.7
Fissile shale. At top occurs a limestone 7 inches thick containing *Camarotœchia andrewsi* and *Pterinea flintstonensis*. At 277 feet horizontally occurs *Homœspira evax* var. *marylandica* abundant and *Pterinea flintstonensis*	282.2	2.4	239.0
Fissile shale. In a thin band of limestone at top occurs *Pterinea flintstonensis* and numerous ostracods.	282.2	0.8	236.6
Fissile shale. A thin band of fossiliferous limestone at top	300.2	4.8	235.8
Fissile shale. At the top in a band of limestone 4 inches thick occurs *Camarotœchia andrewsi* in great abundance	312.2	4.3	231.0
Fissile shale. At the top occurs a fossiliferous limestone 4 inches thick containing *Camarotœchia andrewsi* abundant and *Clidophorus nitidus*	330.8	5.1	226.7

Traverse N. 55° W. Altitude of turn 1039 A. T.

Fissile shale. At the top is blue limestone in courses 6 inches thick, interbedded with shale, containing *Orbiculoidea clarki, Camarotœchia andrewsi, Pterinea flintstonensis* common, ostracods	354.8	7.3	221.6
Fissile shale, N. 55° E. 10° E. At the top a thin bed of limestone contains *Homœospira evax* var. *marylandica, Pterinea flintstonensis, Dizygopleura halli*	378.3	7.9	214.3
Fissile shale. A bed of limestone 5 inches thick at top. N. 55° E. 14° E.	391.0	3.7	206.4
Fissile shale. Thin limestone at top. N. 65° E. 11° E.	400.8	4.2	202.7
Fissile shale. A bed of limestone 6 inches thick at top. N. 47° E. 19° E.	406.8	2.7	..
Strata repeated by a minor fold between 406.8 and 420.9	420.9	..	198.5

Traverse N. 39° W. Altitude of turn 1027 A. T.	Horizontal distance from beginning to bottom of beds Feet	Thickness Beds Feet	Total Feet
Fissile gray shale. At the top are beds of brown and blue limestone, N. 25° E. 30° E. and N. 35° E. 30° E.	439.1	10.8	195.8
Fissile shale, N. 55° E. 12° E. and N. 45° E. 14° E. A band of limestone 5 inches thick at top contains *Clidophorus nitidus*, *Orthoceras* sp., ostracods......	457.9	6.2	185.0
Fissile shale. A bed of limestone 10 inches thick at top contains *Orbiculoidea clarki* rather numerous, *Rhipidomella hybrida*, *Homœospira evax* var. *marylandica* very numerous and large..................	478.9	6.7	178.8
Fissile shale. A thin band of limestone at top contains *Rhipidomella hybrida*, *Camarotœchia andrewsi*, *Homœospira evax* var. *marylandica*. At 483.4 occur numerous ostracods	483.4	1.50	132.1
Fissile shale. At top is a thin bed of limestone.......	497.9	5.61	130.6
Interbedded blue limestone and fissile shale. At the top a thin bed of limestone contains *Camarotœchia andrewsi* abundant, cf. *Pterinea flintstonensis*. At 508.7 and 517 feet horizontally *Homœospira evax* var. *marylandica* occurs in great numbers..........	582.3	30.8	125.6
Concealed in part. This interval consists of shale with a few thin interstratified beds of limestone. A single course of limestone 5 inches thick occurs at 636.8 horizontally, 15.7 feet below top of unit, containing *Dalmanella elegantula*. N. 55° E. 14° E. At two other points the rocks dip 6° E. and 8° E...	639.3	22.1	134.8

Traverse N. 33° W. Altitude of turn 998 A. T.

Largely concealed. In part interbedded shale and limestone N. 55° E. 10° E. N. 55° E. 14 ° E. N. 35° E. 3° E. At 393 feet horizontally, 9 feet below top of unit, occurs a bed of limestone containing numerous unidentified pelecypods	772.3	28.5	112.7
The underlying beds are much folded, their thickness being measured directly.			
Thin-bedded limestone and some interbedded drab shale. The limestone beds vary from 1 to 6 inches in thickness. The bottom of this unit is terminated apparently by a thrust fault. In this unit occur *Homœospira evax* var. *marylandica*, *Pterinea flintstonensis* common, *Hormatoma hopkinsi* common, ostracods	788	4.5	784.2
Center of minor anticline..........................	793	..	..

	Horizontal distance from beginning to bottom of beds Feet	Thickness Beds Feet	Thickness Total Feet
Thrust fault, displacement slight. The underlying beds may be repeated but the section is described as though no repetition occurred	794	..	..
Crystalline limestone. This bed contains *Camarotœchia andrewsi, Homœospira evax* var. *marylandica, Pterinea flintstonensis, Hormatoma* sp. in great profusion, and ostracods. A foot above the bottom of this unit is a bed of limestone 7 to 9 inches thick, the upper surface of which is covered with numerous imperfectly preserved bryozoa. The *Hormatoma zone*	805.6	5.0	79.7
Beds between 806.5 and 854 are repeated by folding. At 854 occurs the 7-inch bed seen at 805 feet	854	..	..
Center of anticline	881	..	..
Center of anticline formed by crystalline limestone of *Hormatoma zone*	987.5	..	..
Sharp turn of road to left in descending hill	1000	..	..
Point of intersection of lines passing through center of road above and below turn	1081	..	..
Interbedded limestone and shale. Near the top of this unit occur *Homœospira evax* var. *marylandica, Whitfieldella* sp. small, *Pterinea flintstonensis*	..	1.0	74.7
Interbedded shale and limestone. The lower 2 feet of this unit consists largely of shale. 6.2 feet above base of unit occur *Pterinea flintstonensis;* 4.4 feet above base occur *Homœospira evax* var. *marylandica, Hormatoma hopkinsi*	..	9.0	73.7
Concealed. This interval extends from center of the anticline seen at 88 feet horizontally to the center of the anticline exposed on the lower turn of the road	..	14.0	64.7
The remainder of the section is exposed on the lower turn of the road.			
Argillaceous limestone containing near base *Homœospira evax* var. *marylandica* and ostracods	..	0.8	50.7
Fissile drab shale with some interstratified thin beds of impure argillaceous and arenaceous limestone containing *Whitfieldella* cf. *marylandica, Hormatoma* sp., ostracoda	..	2.0	49.9
Interbedded argillaceous limestone and fissile shale. Three feet above base of unit occur *Homœospira evax* var. *marylandica, Hormatoma* sp., ostracoda. At the base occur *Lingula* sp., *Clidophorus nitidus,* ostracoda	..	3.5	47.9

FIG. 1.—VIEW OF BALTIMORE AND OHIO RAILROAD CUT AT PINTO SHOWING McKENZIE, WILLS CREEK, AND TONOLOWAY FORMATIONS.

FIG. 2.—DETAIL OF TONOLOWAY IN CUT SHOWN IN FIG. 1.

P.78B

	Horizontal distance from beginning to bottom of beds Feet	Thickness Beds Feet	Thickness Total Feet
Hard, blue limestone penetrated by calcite veins, containing cf. *Orbiculoidea clarki*, *Homœospira evax* var. *marylandica*, ostracoda	..	0.4	44.4
Interbedded shale and argillaceous limestone containing *Camarotœchia andrewsi*, ostracoda	..	4.0	44.
Concealed	..	40	40
Approximate thickness of McKenzie formation exposed			300

B. Section of Lower McKenzie and Rochester Formations

This section is to be seen a little less than half a mile south of the National Road upon the second county road west of the Six-Mile House, leading south. It embraces the lower beds of the McKenzie formation and the entire Rochester formation.

	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
McKENZIE FORMATION				
Fine-grained, dark limestone with an occasional dark shale parting. Many *Reticularia* cf. *bicostata* near base	5	0	15	11
Dark-blue limestone	2	0	10	11
Mostly olive to dark shale, beds of limestone at top and 1 foot above bottom. Lower limestone contains *Dalmanella elegantula*, *Reticularia bicostata* and *Euklœdenella longula*	3	0	8	11
Dark olive argillaceous shale, some dark-blue impure limestone, much covered	3	5	5	11
Thick-bedded impure limestone, fine texture, some rusty spots and calcite veins	2	6	2	5
Total thickness of McKenzie formation exposed.			15	11
ROCHESTER FORMATION				
Thin-bedded dark, fine-grained impure limestone and thin-bedded shale, containing *Drepanellina clarki*. *Dizygopleura proutyi*, *D. symmetrica*, *Æchmina abnormis*, *A. spinosa*, *A. postica*, *Beyrichia veronica*	3	9	56	11
Limestone containing *Whitfieldella marylandica*	0	4	53	2
Shale	0	5	52	10
Dark-gray limestone with white veins almost made up of *Whitfieldella marylandica*	0	8	52	5

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Drab shale. At its base a band of impure gray limestone contains *Pholidops squamiformis, Schuchertella elegans, Tentaculites* cf. *niagarensis, Drepanellina clarki, Dizygopleura symmetrica, D. proutyi, Æchmina abnormalis, A. spinosa, Beyrichia veronica*	2	4	51	9
Drab shale. A bed of sandstone 8 inches thick at its base, contains *Stropheodonta corrugata, Dalmanella elegantula, Camarotœchia neglecta, Homalonotus delphinocephalus,* many crinoid rings. The fossils are poorly preserved..............................	6	2	49	5
Drab shale. A thin band of sandstone at its base.....	7	3	43	3
Drab to olive shale carrying *Stropheodonta corrugata* throughout. *Camarotœchia neglecta* and *Uncinulus Stricklandi* occur 5 feet 6 inches above base or unit. *Dizygopleura symmetrica* and *Æchmina spinosa* 4 feet above base. *Uncinulus stricklandi* and *Favosites* sp. 2 feet above base........................	13	6	36	0
Keefer Sandstone Member				
Massive sandstone. Upper 18 inches ferruginous. Many *Camarotœchia neglecta* are found 1 foot 6 inches to 7 feet below top of this sandstone.........	22	6	22	6
Total thickness of Rochester formation........			56	11

C. Section of the Upper Part of the Rose Hill Formation

This section begins at the base of the Keefer sandstone, just back of the Six-Mile House, and continues up the road leading to the north from immediately in front of the hotel. It terminates about 65 feet stratigraphically below the Cresaptown iron sandstone. The measurements in this portion of the section are approximate. The Keefer sandstone is about 20 feet thick.

	Thickness	
ROSE HILL FORMATION	Beds Feet	Total Feet
Greenish to red shale with some sandstone and limestone beds. Toward the top are more limestone and more fossils. This unit contains *Stropheodonta corrugata, Dalmanella elegantula, Camarotœchia neglecta, Reticularia* cf. *bicostata, Cœlospira sulcata, Liocalymmene clintoni.* Seven feet below top occur *Dizygopleura macra, Plethobolbina typicalis, Zygosella vallata, Z. cristata, Mastigobolbina typus, M. typus angulata......*	50	550

	Thickness Beds Feet	Total Feet
Olive, more or less rusty shale with sandstone bands which thicken and become more fossiliferous toward the top. Upper portion of the unit contains *Camarotœchia neglecta, Tentaculites minutus*, and crinoid stems. Thirty feet below top occur *Zygosella vallata nodifera, Mastigobolbina nucula, M. ultima*. The *Bonnemaia rudis zone*	184	500
Dark-colored shale with thin sandstone layers and many indistinct impressions of plants	10	316
Hackly, arenaceous, greenish to brown shale containing *Cœlospira hemispherica*	6	306
Olive, rusty, argillaceous shale carrying *Cœlospira hemispherica* and *Tentaculites minutus*	43	300
Concealed	27	257
Dark-colored shale with sandstone in thin layers. This unit bears numerous faint plant impressions, *Stropheodonta* sp., *Camarotœchia neglecta, Calymmene cresapensis*	18	230
Rusty, olive, argillaceous shale with sandstone layers containing crinoid stems, *Dalmanella* cf. *elegatula, Cœlospira hemispherica, C. sulcata, Calymmene* sp., *Mastigobolbina lata*	23	212
Red ferruginous sandstone ("iron ore") in two bands separated by shale parting, carrying in this immediate locality from 6 inches to 8 feet in thickness. The *Cresaptown iron sandstone*. Average thickness	4	189
Olive, and often rusty argillaceous shales with few fossils bearing *Camarotœchia neglecta, Cœlospira hemispherica*	65	185
Concealed to base of formation. Estimated to be about	120	120
Approximate thickness of Rose Hill formation		550

C. Sections in Tussey Mountain Anticline

VII. Section at Flintstone

An excellent partial section of the McKenzie and Rochester formations and of the upper beds of the Rose Hill formation is exposed on Flintstone Creek, northwest of the village of Flintstone.

About 150 feet of the upper part of the McKenzie formation may be seen on the east bank of the creek, nearly ½ mile in an air line north of the village. The middle beds of the McKenzie are largely concealed along the stream above this point though here and there they may be seen, but not with sufficient continuity to permit the construction of a section. The Rochester formation and the upper beds of the Rose Hill formation are exposed near the mouth of a small branch which enters Flintstone Creek from the northeast 3500 feet, in an air line, northwest of the bridge at Flintstone. The lower strata are observed in the bed of the branch and on the east bank of the ravine, a short distance above its mouth.

The Rochester fauna occurs in profusion in the shale beds overlying the Keefer sandstone. *Dalmanites limulurus* is not confined, however, to these beds as in the Cumberland section, but is found also in the Keefer sandstone and a variety occurs in the immediately underlying beds. The upper shale beds of the Rochester formation are thinner than at Cumberland, while the Keefer sandstone is thicker. This locality, hence, clearly manifests conditions which are intermediate between those observed at Hancock and those seen at Cumberland, corresponding in this respect with its geographic position.

The *Uncinulus obtusiplicatus* zone of the Upper McKenzie occupies a position similar to that at which it occurs at Grasshopper Run and also contains fossils of Niagaran type as it does at the latter locality.

The section begins at the cliff formed by the Bloomsburg red sandstone on the east bank of Flintstone Creek, 2000 feet in an air line north of the village, and extends thence along the creek for a distance of ⅓ mile, ending a short distance beneath the Keefer sandstone.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
WILLS CREEK FORMATION				
Bloomsburg Member				
Reddish-brown, fossiliferous sandstone	4	0	15	0
Reddish-brown, arenaceous shale	11	0	11	0
MCKENZIE FORMATION				
Olive to dark-gray platy shales, lower 7 feet interstratified with thin limestone and sandstone layers, carrying *Butrotrephis gracilis* var. *intermedia*, *Lingula* sp.	13	6	295	6
Massive dark, bluish-gray limestone with *Pterinea flintstonensis* poorly preserved, *Dizygopleura acuminata*, *D. acuminata prolapsa*, *D. swartzi*. *Homœospira* sp. is abundant toward bottom	5	6	282	0
Drab shale mostly concealed	14	0	276	6

	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Interbedded drab shale and very fossiliferous dark-gray limestone containing *Pholidops* sp., *Dalmanella elegantula*, *Camarotœchia andrewsi*, *Uncinulus obtusiplicatus*, *Spirifer mackenzicus*, *Trematospira camura*, *Cuneamya ulrichi*, *Calymene niagarensis* var. *restrictus*, *Tentaculites* sp., crinoid stems, *Dizygopleura acuminata*, *D. swartzi*, and bryozoa. This horizon corresponds to that found 35 feet below the red layers of the Bloomsburg at Grasshopper Run	7	0	262	6
Gray shale	6	0	252	6
Interbedded dark shale and dark limestone, more shale than limestone, containing numerous *Camarotœchia andrewsi*	5	0	249	6
Mostly dark-gray shale. Some thin impure limestone containing *Camarotœchia andrewsi* abundant	5	0	244	6
Calcareous sandstone containing few fossils, including *Camarotœchia andrewsi*, *Homœospira evax* var. *marylandica*, *Pterinea flintstonensis*, *Tentaculites niagarensis* var. *cumberlandiæ*	1	0	239	6
Mostly shale, some thin impure limestone	3	0	238	6
Dark-colored limestone with thin shale parting. *Camarotœchia andrewsi* in great abundance	1	4	235	6
Drab shale	2	0	234	2
Interbedded dark-gray shale and thin-bedded dark-blue limestone. Limestone layers toward center carrying many *Camarotœchia andrewsi*	8	8	232	2
Impure dark limestone with *Homœospira evax* var. *marylandica*, *Æchmina inequalis*, *Kyammoides tricornis*, *Beyrichia mesleri*, *Euklœdenella dorsata*, *E. sinuata*, *E. sinuata angulata*, *E. sinuata proclivis*, *Klœdenella gibberosa*, *K. subovata*, *Dizygopleura gibba*, *D. punctata*, *D. bulbifrons*, *Bythocypris phillipsiana*	1	0	223	6
Shale. *Butrotrephis gracilis* var. *intermedia*	12	0	222	6
Sandstone, somewhat argillaceous and weathering yellow	1	0	120	6
Arenaceous shale above; at base a band of limestone 6 inches thick	2	6	209	6
Limestone weathering buff	3	6	207	0
Hackly shale	4	0	201	6
Dark-gray shale below, with 8 inches of black impure limestone at top containing *Lingula subtruncata* and many ostracods of the genera *Klœdenella*, *Euklœdenella*, *Dizygopleura*	12	8	197	6

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Impure limestone	0	6	184	10
Shale	1	0	184	4
Dark impure limestone	8	0	183	4
Dark-gray shale	2	10	175	4
Dark, impure limestone with shale parting	1	6	172	6
Interbedded gray shale and impure dark limestone about equal in amount	21	0	171	0
Concealed in large part. Lower beds dark limestone. About 30 feet above the base occur many *Euklœdenella indivisa, E. umbonata, E. umbilicata, E. primitoides, E. primitoides minor, Klœdenella scapha, K. transitans, Dizygopleura subdivisa, D. micula, D. pinguis, D. concentrica subquadrata.* About	150	0	150	0
Approximate thickness of McKenzie formation exposed			296	0

The ostracods of the McKenzie of this section are practically the same throughout every fossiliferous bed, comprising *Klœdenella nitida, Dizygopleura halli, D. intermedia, D. perrugosa, Beyrichia moodyi.*

ROCHESTER FORMATION	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Dark-blue limestone containing numerous *Whitfieldella marylandica*	0	6	37	10
Dark-gray shale. At its base is a band of crystalline, gray, fossiliferous limestone containing *Stropheodonta corrugata, Leptæna rhomboidalis, Schuchertella tenuis, Dalmanella elegantula, Camarotœchia neglecta, Atrypa reticularis, Diaphorostoma niagarense, Calymene niagarensis, Homalonotus delphinocephalus, H. lobatus, Dalmanites limulurus*	8	4	37	4
Gray shale. At its base is a band of crystalline, gray limestone, very fossiliferous containing *Stropheodonta corrugata, Leptæna rhomboidalis, Camarotœchia neglecta, Atrypa reticularis, Diaphorastoma niagarense, Dalmanites limulurus*	9	4	32	0
Drab shale. At its base is a band of arenaceous limestone, very fossiliferous, carrying *Stropheodonta corrugata, Dalmanella elegantula, Camarotœchia neglecta, Uncinulus stricklandi, Homalonotus delphinocephalus, H. lobatus. Dalmanites limulurus*	2	0	19	8
Arenaceous shale containing *Stropheodonta corrugata* and *Uncinulus stricklandi* in great abundance	0	8	17	8

Keefer Sandstone Member	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Heavy-bedded, gray sandstone with a few calcareous layers near bottom. The lower 5 feet of this sandstone contain *Stropheodonta corrugata*, *S. convexa*, *Leptæna rhomboidalis*, *Dalmanella elegantula*, *Camarotœchia neglecta*, *Atrypa reticularis*, *Spirifer niagarensis*, *Spirifer crispus* ?, *Cœlospira sulcata*, *Hormatoma* sp., *Diaphorastoma niagarense*, *Platyceras* sp., *Coleolus* sp., *Calymene niagarensis*, *Dalmanites limulurus*. The upper 5 feet contain *Cystid* sp., *Stropheodonta corrugata*, *Uncinulus stricklandi*, *Spirifer eudora*	17	0	17	0
Total thickness of Rochester formation described			37	10
ROSE HILL FORMATION				
Shale	1	8	40	7
Light-gray crystalline limestone and interbedded shale carrying *Stropheodonta corrugata*, *S. convexa*, *Leptæna rhomboidalis*, *Camarotœchia neglecta*, *Atrypa reticularis*, *Cœlospira sulcata*, *Dalmanites limulurus*.	1	8	37	3
Light crystalline limestone carrying *Leptæna rhomboidalis*, *Chonetes novascoticus*, *Spirifer radiatus*, *Cœlospira sulcata*, *Liocalymene clintoni*	1	1	35	7
Drab to olive shale with thin limestone bands near bottom carrying *Chonetes novascoticus*, *Dalmanella elegantula*, *Camarotœchia neglecta*, *Liocalymene clintoni*, and many crinoid stems	11	6	34	6
Reddish-colored, thin-bedded shale with two calcareous sandstone bands 3 and 7 feet respectively above the bottom with sandstone layers bearing *Chonetes novascoticus*, *Cœlospira sulcata*, and *Tentaculites* sp.	23	0	23	0
Thickness of Rose Hill formation described			40	7

The occurrence of *Dalmanites limulurus* in the upper beds of the Rose Hill formation is notable.[1]

D. Sections in Cacapon Mountain Anticline

VIII. Section East of Great Cacapon, West Virginia

A good section of the Rochester formation and of portions of the overlying McKenzie and underlying Rose Hill formations is exposed on the

[1] See foot-note, page 200.

Baltimore and Ohio Railroad 1½ miles east of Great Capapon. The beds are folded into a sharp syncline, the Keefer sandstone being finely exposed in its western limb.[1] The strata beneath the Keefer sandstone are unusually arenaceous at this locality and could fittingly be combined with the Keefer but contain the fauna of the upper Rose Hill of Cumberland. A very interesting feature of this section is the occurrence of *Dalmanites limulurus* 23 feet beneath the base of the Keefer sandstone, a feature which led Ulrich and Stose to refer these beds to the Rochester formation in their discussion of the area embraced in the Pawpaw-Hancock Folio of the U. S. Geological Survey. The section resembles, in this respect, that seen at Flintstone.

	Thickness			
	Beds		Total	
McKENZIE FORMATION	Feet	Inches	Feet	Inches
Interbedded, dark-blue limestone and shale	20	0	..	..
Concealed. Thickness of this interval is unknown	..	..	..	..
Dark-gray, rather fissile shale and interbedded, impure, lenticular, light-weathering limestone, more shale than limestone	11	0	48	9
Drab, fissile shale, breaking into large thin plates, intersected by joints, an occasional thin bed of impure limestone	6	2	37	9
Dark-colored limestone, conglomerate at top	0	9	31	7
Fissile, drab shale, a few thin impure limestone lenses near middle	2	3	30	10
Limestone conglomerate, pebbles flat ½ to 2 inches thin dimension, usually parallel to bedding, weathered surfaces gray. Many ostracoda	0	7	28	7
Interbedded fissile gray shale and thin-bedded blue limestone	28	0	28	0
Thickness of McKenzie formation described			48	9
ROCHESTER FORMATION				
Bluish-gray limestone, highly fossiliferous with many calcite veins. The limestone weathers to a slightly greenish tone. This unit contains *Pholidops squamiformis, Stropheodonta corrugata, Reticularia bicostata, Trematospira camura, Nucula* sp., *Dalmanites limulurus, Klœdenia cacaponensis*	0	8	22	5

[1] This section was described by G. W. Stose, U. S. Geol. Survey, Pawpaw-Hancock Folio, No. 179, 1912, p. 4.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Interbedded gray shale and bluish limestone. Seventeen inches above Keefer sandstone occur *Dizygopleura lacunosa, D. intermedia antecedens, D. intermedia cornuta*	1	1	21	9
Grayish-blue limestone with calcite veins, highly fossiliferous bearing *Pholidops squamiformis, Stropheodonta corrugata, Dalmanella elegantula, Rhipidomella* cf. *hybrida, Camarotœchia neglecta, Whitfieldella marylandica, Nucula* sp., *Tentaculites* sp., *Encrinus ornatus, Dalmanites limulurus, Æchmina spinosa, Calymmene niagarensis*	0	6	20	8
Arenaceous shale	0	2	20	2
Keefer Sandstone Member				
Massive sandstone above with interbedded shale and limestone below comprising the following beds:				
Massive gray sandstone with pitted surfaces containing, a little distance below its center, *Stropheodonta corrugata, Dalmanella elegantula, Rhipidomella* cf. *hybrida, Camarotœchia neglecta, Spirifer* sp., *Pterinea* cf. *emacerata, Homalonotus delphinocephalus*	6	9	20	0
Shaly sandstone	0	7	13	3
Massive gray sandstone with pitted surfaces and *Scolithus keeferi*	12	8	12	8
Thickness of the Rochester formation			22	5
ROSE HILL FORMATION				
Alternating thin beds of sandstone and dark-gray shale.	2	0	88	0
Thin alternating laminæ of sandstone and drab shale. A few thicker sandstone bands also occur. The shales are penetrated by openings ⅛ inch in diameter filled with sand. These resemble worm borings. A fault occurs here	2	6	86	0
Interbedded sandstone and shale	1	0	83	6
Drab shale	0	6	82	6
Interbedded, bluish-gray limestone and shale. The limestone has inclusions of thin films of shale and is highly fossiliferous but fossils cannot be easily gotten out or determined. *Cœlospira sulcata* observed	0	10	82	0
Drab shale, occasional thin sandstone bed near top containing *Chonetes* sp., *Cœlospira sulcata*	12	6	81	2
Bluish-gray limestone with some thin shale partings containing *Cœlospira sulcata*	0	6	68	8

	Thickness: Beds, Feet	Beds, Inches	Total, Feet	Total, Inches
Sandstone bluish-gray	0	2	68	2
Bluish-gray sandstone, somewhat fossiliferous, passing on strike into more fossiliferous limestone. This unit contains *Rhipidomella hybrida, Camarotœchia* sp., *Atrypa reticularis, Cœlospira sulcata,* trilobite fragments	0	6	68	0
Cross-bedded sandy shale and sandstone with a bed of limestone 1 foot thick in middle, containing *Beyrichia postulata, B. distincta, B. proutyi, B. consimilis*	2	6	67	6
Interbedded shale and crystalline gray fossiliferous limestone bearing *Cornulites* cf. *rosehillensis*. At top occur *Mastigobolbina typus, M. arguta, M. rotunda, M. trilobita, M. arctilimbata, Plethobolbina typicalis, Beyrichia lakemontensis, Bonnemaia celsa, Dizygopleura loculata, Stropheodonta corrugata, S.* cf. *convexa, Leptæna rhomboidalis, Chonetes* sp., *Dalmanella elegantula, Rhipidomella* cf. *hybrida, Camarotœchia neglecta, Dalmanites limulurus, Diaphorostoma niagarense, Liocalymmene clintoni*	4	6	65	0
Alternating, rather fissile olive to drab shale, thin calcareous sandstone and limestone. Some of the limestones are fossiliferous, *Chonetes novascoticus* occurring 11, 14, and 16 feet below top. Nineteen feet below top are many *Dalmanella elegantula. Zygosella vallata* occurs 16 feet below top	36	6	60	6
Red ferruginous sandstone and interbedded shale ("iron ore") consisting of a massive ferruginous sandstone 2 feet 8 inches thick above, and olive to drab shale and thin ferruginous sandstone below	10	0	24	0
Olive to drab, rather fissile shale with occasional sandstone layers	14	0	14	0
A fault occurs here of unknown throw, rendering the stratigraphic position of the underlying rocks insecure.				
Total thickness of the Rose Hill formation described			88	0

The large amount of sandstone in the upper part of the Rose Hill at this place is notable. Because of this fact Ulrich and Stose referred these beds to the Keefer sandstone in their discussion of this locality in the Pawpaw-Hancock folio of the U. S. Geological Survey and made the

Keefer sandstone McKenzie. The ostracod studies, however, led Ulrich and Bassler to consider these beds pre-Rochester which is in harmony with the work of the authors who showed that the Rochester fauna lies above the Keefer sandstone at Great Cacapon.[1]

IX. Section East of Tonoloway

A section extending from the Bloomsburg red shale to the base of the upper beds of the Rose Hill formation is seen on the Western Maryland Railway about 1½ miles east of Tonoloway. This locality is nearly opposite the exposure east of Great Cacapon described in the foregoing pages. This section, like the last one described, affords an excellent exposure of the Rochester formation.

WILLS CREEK FORMATION

Bloomsburg Member

Red sandstone and shales.

	Thickness			
	Beds		Total	
McKENZIE FORMATION	Feet	Inches	Feet	Inches
Greenish arenaceous shale	5	0	229	11
Drab shale and thin bands of dark limestone	11	0	224	11
Drab, calcareous shale containing numerous ostracods.	4	0	213	11
Dark shale and thin bands of dark limestone largely concealed	77	0	209	11
Red arenaceous shale. The *McKenzie Red Bed*	5	0	132	11
Drab shale, arenaceous above with interbedded dark impure limestone which weathers with pitted surfaces. Some beds of limestone are very fossiliferous, containing numerous *Camarotœchia andrewsi* 18 feet above its base, *Hormatoma* sp. 13 to 14 feet above its base, and many ostracods 7 feet above base	43	0	127	11
Dark, massive, calcareous shale with a band of dark impure limestone 5 inches thick at its base containing *Hormatoma* sp	9	5	84	11
Interbedded thin beds of lenticular, dark-blue limestone and drab shale containing numerous *Hormatoma* sp. Near center is a bed of limestone conglomerate 6 inches thick	5	6	75	6
Interbedded dark limestone and drab shale a little thicker-bedded than the above	8	0	70	0
Mostly concealed	11	0	62	0

[1] Ulrich formerly identified the Dalmanites in these beds as *D. limulurus*. He is now inclined to consider it distinct from the latter species.

	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Arenaceous drab shale	1	6	51	0
Blue limestone containing *Hormatoma* sp., ostracods	0	6	49	6
Impure dark-blue limestone	1	6	49	0
Hackly drab shale	1	6	47	6
Dark impure sandy limestone	1	0	46	0
Interbedded drab shale and thin-bedded dark-blue limestone. This unit bears *Camarotœchia andrewsi*, *Homœospira evax* var. *marylandica*, *Spirifer* sp. large form, *Orthoceras* sp., *Beyrichia moodyi*, 4 feet beneath the top the rocks are crowded with *Euklœdenella indivisa*, *E. umbilicata*, *E. primitioides* and many species of *Dizygopleura*, especially *D. stosei*	11	0	45	0
Limestone conglomerate layer at top, underlain by interbedded dark, impure limestone and drab shale containing, at base, *Beyrichia moodyi* and species of *Dizygopleura* especially *D. stosei*	6	6	34	0
Interbedded fissile drab shale and dark-blue, fine-grained impure lenticular limestone. Seven feet below top occur *Æchmina bimuralis*, *Euklœdenella brevis*, *E. simplex*, *E. foveolata*, *E. bulbosa*, *E. similis*, *E. sulcifrons*, *E. sinuata proclivis*, *E. longula*, *Klœdenella cacaponensis*, *K. scapha*, *Dizygopleura stosei*, *D. falcifera*, *Bythocypris pergracilis*	28	0	28	0
Approximate thickness of McKenzie formation			229	11

ROCHESTER FORMATION

	Beds Feet	Beds Inches	Total Feet	Total Inches
Dark-colored, fine-grained, impure limestone above, olive shale below, containing *Buthotrephis* sp., *Spirifer* sp., *Reticularia* cf. *bicostata*, *Trematospira* cf. *camura*, *Nucula* sp	0	4	26	7
Fissile, olive shale[1]	0	3	26	3
Dark, semicrystalline limestone in part a limestone conglomerate carrying *Favosites* sp., *Spirifer* sp., *Reticularia* cf. *bicostata*, *Trematospira camura*, *Nucula* sp., *Homalonotus delphinocephalus*, *Orthoceras* sp., *Calymene* sp., *Æchmina spinosa*	0	8	26	0
Olive, argillaceous shale	0	4	25	4
Bluish-gray, very fossiliferous limestone containing *Cornulites* sp., with marked longitudinal striations, *Spirifer* sp., *Reticularis bicostata*, *Trematospira camura*, *Whitfieldella marylandica*, *Hormatoma* sp.,				

[1] Ulrich and Bassler made this unit the base of the McKenzie formation.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis	0	4	25	0
Bluish-gray crystalline limestone carrying *Buthotrephis* sp., *Pholidops squamiformis, Stropheodonta corrugata, Schuchertella* sp., *Camarotœchia neglecta, Dalmanella elegantula, Reticularia bicostata, Trematospira* cf. *camura, Clidophorus nitidus, Orthoceras* sp., *Encrinus ornatus, Calymmene niagarensis, Dalmanites limulurus, Æchmina abnormis, Drepanellina clarki*	0	4	24	3
Olive to drab arenaceous shale bearing *Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis, A. spinosa, Beyrichia veronica*	0	4	23	11
Bluish-gray limestone containing *Pholidops* cf. *squamiformis, Stropheodonta corrugata, Schuchertella elegans, Dalmanella elegantula, Camarotœchia neglecta, Atrypa reticularis, Whitfieldella marylandica, Clidophorus nitidus, Hormatoma* sp., *Coleolus* sp., *Tentaculites niagarensis* var. *cumberlandiæ, Cornularia niagarensis, Dizygopleura symmetrica, Laccoprimitia ulrichi, Aparchites alleghaniensis, Drapanellina clarki, Æchmina abnormis, A. spinosa, Beyrichia veronica*	0	6	23	7
Olive to drab shale and very thin sandstone lenses carrying *Pholidops squamiformis, Stropheodonta corrugata, Dalmanella elegantula, Camarotœchia neglecta, Clidophorus nitidus, Tentaculites* cf. *niagarensis, Calymene* cf. *niagarensis, Homalonotus delphinocephalus, Dalmanites limulurus, Drepanellina clarki, D. simplex, Dizygopleura symmetrica, Æchmina spinosa, A. abnormis, A. postica, Beyrichia veronica*	0	8	23	1
Friable red sandstone, calcareous before weathering. This may represent the *Roberts iron ore* of the western sections	0	5	22	5
Keefer Sandstone Member				
Massive sandstone, calcareous at some places. A band of shale occurs 2 feet below top. About 7 feet above base occur *Pholidops squamiformis, Reticularia bicostata, Trematospira camura, Nucula* sp., *Drepanellina clarki, Dizygopleura symmetrica, Æchmina abnormis, A. spinosa*	22	0	22	0
Total thickness of Rochester formation			26	7

ROSE HILL FORMATION	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Interbedded shale and sandstone....................	18	0	18	0
Concealed.				
Total thickness of Rose Hill formation exposed.			18	0

X. Section at Sir Johns Run

The best exposure of the Rose Hill formation in the vicinity of Hancock is seen one-half to three-fourths of a mile west of Sir Johns Station, on the Baltimore and Ohio Railroad. The Tuscarora formation is well exposed west of the station. A cut extends westward almost a quarter of a mile from the Tuscarora-Rose Hill contact, terminating at the Keefer sandstone member of the Rochester formation. This section is of special interest because it shows that the Rose Hill formation contains a larger number of ferruginous sandstones ("iron ores") in this area than in the western section.

The strata are folded and faulted so that the total computed thicknesses are not altogether reliable.[1]

ROCHESTER FORMATION

Keefer Sandstone Member

Massive sandstone.

ROSE HILL FORMATION Traverse N. 56° E.	Horizontal distance to bottom of beds Feet	Thickness: Beds Feet	Total Feet
Shale with some beds of calcareous sandstone. N. 30° E. 67° W. It is possible that a fault occurs in this unit. Fifteen feet below the top occur *Cœlospira sulcata, Dalmanella elegantula*....................	150.0	61.0	437.7
Ferruginous sandstone varying somewhat in thickness. N. 16° E. 65° E................................	152.0	1.2	376.7
Olive to drab shale with thin bands of sandstone. Possible faulting	437.0	123.5	375.5
Ferruginous sandstone	441.0	1.5	252.0

[1] The horizontal traverse begins at the base of the Keefer sandstone and extends eastward. The measurements were made by tape along the line of telegraph poles.

	Horizontal distance to bottom of beds Feet	Thickness Beds Feet	Thickness Total Feet
Section repeated by minor folding. The ferruginous sandstone bed at 441 feet is seen in the axis of a minor syncline at 575 feet [1]	575.0	..	..
Olive to drab shale and some thin bands of sandstone. About 40 feet below the top of this unit occur *Tentaculites minutus, Liocalymene clintoni, Calymene cresapensis*	806.0	76.0	250.5
Traverse N. 54° E.			
Olive to drab shale and thin sandstone beds. N. 30.9° E. 52° W.	967.0	51.0	174.5
Traverse N. 51° E.			
Olive to drab shale and thin beds of sandstone. N. 28° E. 46° W.	1081.5	31.0	123.5
Ferruginous sandstone	1087.5	2.5	91.5
Traverse N. 51.5° E.			
Olive to drab shale, thin beds of sandstone, N. 28° E. 46° W.	1235.0	42.0	89.0
Olive to drab shale and thin beds of sandstone. N. 36.4° E. 48.6° W.	1508.0	47.0	47.0
Approximate thickness of Rose Hill formation.			437.7

TUSCARORA FORMATION

Massive sandstone.

XI. Section at Grasshopper Run

A section exposing the upper strata of the McKenzie formation and the Keefer sandstone member of the Rochester formation is seen on the Baltimore and Ohio Railroad near the mouth of Grasshopper Run, 2 miles southwest of Hancock. The upper beds of the McKenzie are finely exposed on the hillside a short distance south of the railroad track, beneath the heavy outcropping ledges of the Bloomsburg red sandstone, which forms the top of a small knob east of the run. The Keefer sandstone member of

[1] Strike and dip are as follows: 441 to 538 feet horizontally, N. 30° E. 70° W.; 538 to 670 feet horizontally N. 29° E. 54° W.; 670 to 806 feet horizontally N. 32° E. 59° W.

the Rochester formation and the immediately underlying beds are well exposed south of the railroad track on the west side of the ravine.

This locality affords an excellent collecting ground for the fossils found in the strata between the Bloomsburg and McKenzie red beds.

WILLS CREEK FORMATION

Bloomsburg Member

Red sandstone and shale.

McKENZIE FORMATION	Thickness Beds Feet	Thickness Total Feet
Argillaceous greenish-gray sandstone and some interbedded greenish-gray shale	4	244
Drab to olive fissile shale with numerous thin beds of dark to bluish-gray crystalline limestone and calcareous sandstone. Fossils occur in great profusion in the limestone beds at the following distances in feet above the base of this unit: *Orthoceras* sp., 79; *Lingula* sp., *Clidophorus nitidus*, *Orthoceras* sp., ostracods, 73; *Lingula* sp., *Orthoceras* sp., ostracods, 71; ostracods, 62; *Homœospira evax* var. *marylandica*, *Orthoceras* sp., 56; *Dalmanella cf. elegantula*, *Leptæna rhomboidalis*, *Camarotœchia andrewsi*, cf. *Homœospira evax* var. *marylandica*, 54; *Dalmanella elegantula*, *Camarotœchia andrewsi*, *Uncinulus obtusiplicatus*, *Spirifer mackenzicus*, *Orthoceras* sp., *Calymene niagarensis* var. *restrictus*, *Cordyocephalus ptyonurus*, 52; *Spirifer mackenzicus* abundant, 47-48; *Lingula* sp., 39, 33; *Pterinea flintstonensis*, *Schuchertella* sp., *Beyrichia moodyi*, 21; *Camarotœchia andrewsi*, 50-46, 39, 33, 26, 14, 10	83	240
Red, sandy shale. *McKenzie red beds*	5	157
Olive, very fissile shale, becoming mottled on weathering. Dark, impure limestone at base	30	152
Concealed in large part. Shale and limestone bands	32	122
Concealed in valley	90	90
Approximate thickness of McKenzie formation		244

ROCHESTER FORMATION

Concealed.

Keefer Sandstone Member

Massive sandstone, its base marked by a distinct unconformity	25	25
Thickness of Keefer sandstone member		25

FIG. 1.—VIEW SHOWING THE JUNIATA AT EAST END OF THE NARROWS.

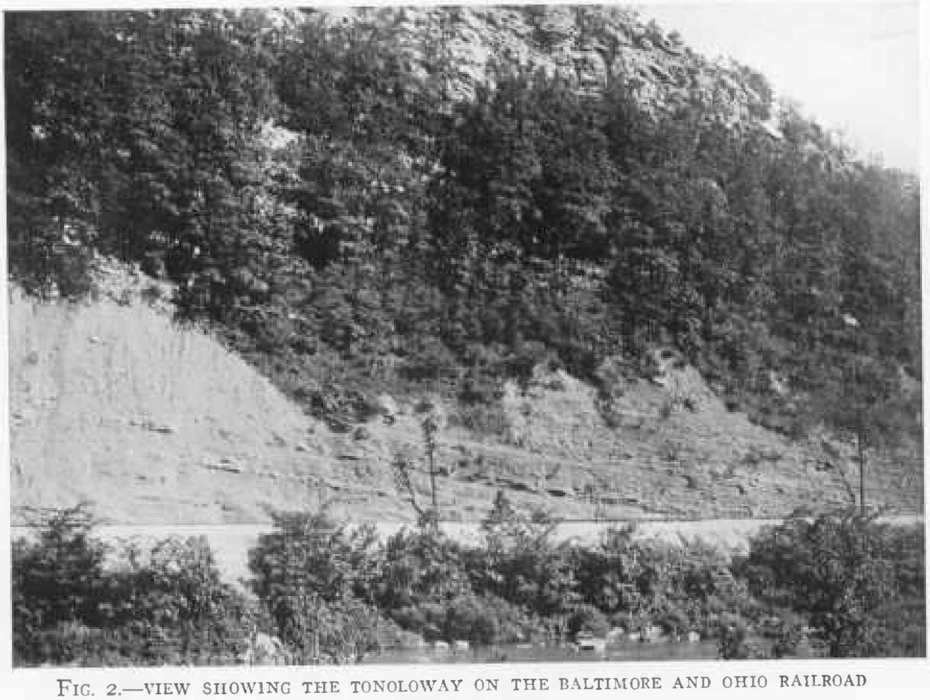

FIG. 2.—VIEW SHOWING THE TONOLOWAY ON THE BALTIMORE AND OHIO RAILROAD EAST OF PINTO.

P.94 B

ROSE HILL FORMATION	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Hard, dark shale	5	0	36	4
Massive sandstone	7	6	31	4
Interbedded shale and sandstone	3	0	23	10
Fissile, olive to drab shale	15	6	20	10
Calcareous sandstone containing *Dalmanella elegantula, Cœlospira sulcata,* ostracods	0	4	5	4
Drab shale with thin bands of limestone. A thin band of sandstone 3 feet below top. This unit contains *Spirifer eudora, Cœlospira sulcata* abundant, ostracods	5	0	5	0
Concealed.				
Total thickness of Rose Hill formation described			36	4

E. Sections in Keefer Mountain Anticline

XII. Section West of Keefer Mountain

This section is exposed in the bed and on the north bank of a small run which rises in a ravine between Dickeys and Keefer mountains and flows due west, entering Licking Creek at a point 1 mile in an air line north of the Pennsylvania-Maryland state line. The section begins approximately 1800 feet east of the mouth of the stream and extends toward the east. The locality is situated in Franklin County, Pennsylvania, about 6 miles northeast of Hancock.

WILLS CREEK FORMATION *Bloomsburg Member*	Thickness	
	Beds Feet	Total Feet
Red sandstone and shale. Thickness about	78	78

MCKENZIE FORMATION		
Concealed, probably shale	17	224
Red, sandy shale	1	207
Concealed, probably largely shale	74	206
Red, sandy shale. *McKenzie red beds*	24	132
Mostly concealed, occasional exposure of drab shale	108	108
Total thickness of the McKenzie formation		224

	Thickness	
	Beds Feet	Total Feet
ROCHESTER FORMATION		
Keefer Sandstone Member		
Massive sandstone. This sandstone is finely exhibited on the crest of the knob through which the Franklin-Fulton county boundary line passes and which lies north of the run..........	25	25
Total thickness of the Rochester formation exposed.......		25
ROSE HILL FORMATION		
Largely concealed. Portions of this unit exposed nearby show it to consist chiefly of shale with thin interbedded sandstones and arenaceous limestones. From 5 to 20 feet below the Keefer sandstone occur *Chonetes novascoticus, Camarotœchia neglecta, Cœlospira hemispherica, Tentaculites minutus, Liocalymmene clintoni, Dizygopleura symmetrica*..........................	93	413
Red ferruginous sandstone..................................	50	320
Largely concealed. This unit probably consists chiefly of shale with thin interbedded beds of sandstone. The following fossils were collected from the lower part of the unit on the east slope of the hill mentioned above: *Chonetes novascoticus, Camarotœchia neglecta* large form, *Tentaculites minutus, Liocalymmene clintoni, Calymene cresapensis* abundant................	90	270
Olive shale with a few thin bands of sandstone..................	180	180
Concealed.		
Total thickness of Rose Hill formation exposed..........		413

F. Sections in Fairview Mountain Anticline

The Fairview Mountain anticline is attended by several subordinate anticlines in Maryland. Two of these, the Cross Mountain and the Hearthstone Mountain anticlines, are west of Fairview Mountain, while the Powell-Johnson Mountain anticline lies east. The first of the following sections is in the Cross Mountain anticline, the second in the Fairview Mountain anticline, and the third in the Powell-Johnson Mountain anticline.

XIII. Section on Rabble Run[1]

WILLS CREEK FORMATION

Bloomsburg Member

Red shale and sandstone seen on road east of bridge.

[1] This section was measured with tape by C. K. Swartz assisted by G. Taylor.

McKENZIE FORMATION	Horizontal distance from beginning of traverse to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
The section is measured along the county road, the traverse beginning 450 feet east of the center of bridge. Strike and dip in this part of the section N. 54° E. 24° E., average of three observations......	..	..	..
Traverse due west			
Fissile shale. A bed of fossiliferous, crystalline, blue limestone at base, contains *Camarotœchia andrewsi* abundant, and *Orthoceras mackenzicus*............	97.0	31.0	265.1
Fissile shale, a bed of crystalline blue limestone at base contains *Camarotœchia andrewsi, Klœdenella nitida, Dizygopleura halli, D. intermedia, D. perrugosa* and *Beyrichia moodyi*....................	115.0	5.5	234.1
Fissile shale. A band of blue limestone at base contains *Camarotœchia andrewsi*....................	122.0	2.5	238.6
Fissile shale. A band of blue limestone at base contains *Camarotœchia andrewsi*	134.0	4.0	226.1
Fissile shale. A band of blue limestone at base contains *Camarotœchia andrewsi*....................	159.0	8.0	222.1
Fissile shale. A band of blue limestone at base contains *Camarotœchia andrewsi*	184.0	8.5	214.1
Red shale	185.0	0.7	205.6
The section is continued in the cliff immediately south of the bridge where the thin band of red shale last described is visible 8 feet below the top of the cliff.			
At top of the cliff 9 feet above the red band there occur in the soil *Camarotœchia andrewsi* abundant, *Spirifer mackenzicus, Klœdenella nitida, Dizygopleura halli, D. intermedia, D. perrugosa* and *Beyrichia moodyi*................		..	..
Interbedded fissile gray shale and numerous bands of blue limestone containing *Spirifer mackenzicus* abundant, *Camarotœchia andrewsi* very abundant 6 to 7 feet above base of unit. *Pterinea flintstonensis* 5 to 6 feet above base........		7.0	212.6
Red shale. This is the same band as the one exposed at 185 feet horizontally upon the county road..................		0.7	205.6
Interbedded fissile gray shale and highly fossiliferous blue crystalline limestone. The limestone contains *Camarotœchia andrewsi* in great profusion in nearly every foot of the beds. Additional fossils are found above the base of this unit as follows: *Homœospira evax* var. *marylandica*, 10; *Clidophorus nitidus*, 2-3; *Pterinea flintstonensis*, 3, 10-14, abundant; *Klœdenella nitida, Dizygopleura halli, D. intermedia, D. perrugosa* and *Beyrichia moodyi*, near base and top of unit....................................		35.5	204.9

	Thickness Beds Feet	Total Feet
The section is continued in a dry run a short distance west of the bridge.		
Red arenaceous shale, upper surface discolored	0.4	169.4
Red argillaceous sandstone	1.2	169.0
Red shale	0.4	167.8
Red and greenish sandstone, discolored in part	3.0	167.4
Fissile green shale	1.2	164.4
Greenish sandstone	1.0	163.2
Red, arenaceous sandstone	11.0	162.2
The section is continued in the bluff which forms the north bank of Rabble Run where the red sandstone seen at the top of the section in the dry run outcrops in the top of the bluff 200 feet northeast of the bridge.		
Interbedded red shale and sandstone. This unit is 32 feet thick and includes at its top the beds exposed in the dry run	13 8	151.2
Massive, argillaceous sandstone	2.0	137.4
Red, arenaceous shale and some interbedded sandstone	13.0	135.4
Massive red sandstone forming a prominent ledge at the bottom of the cliff, 250 feet northeast of the road	8.0	122.4
The section is continued in the cliff 500 feet northeast of the road where the massive red sandstone last described forms a conspicuous projecting ledge in the cliff on the south side of the run. N. 81° E. 12° W.		
Red shale	0.3	114.4
Gray shale	4.0	114.1
Red shale	1.0	110.1
Fissile gray shale	4.5	109.1
Red shale	0.5	104.6
The section is continued on the north side of the run 575 feet northeast of the road.		
Red sandstone	1.1	104.1
Red shale	3.0	103.0
Fissile gray shale above. Concealed below to base of formation approximately	100.0	100.0
Approximate thickness of McKenzie formation		265.0

A notable feature of this section is the great development of Red beds in the McKenzie.

XIV. Section on Lanes Run

This section is situated on Lanes Run, 3 miles in an air line northwest of Clear Spring, Maryland, and 1 mile southwest of Stone Cabin Gap. It is 1½ miles southeast of the preceding section. The lower part of the

McKenzie formation is exposed in the bed of Lanes Run. The massive ledges of the Keefer sandstone outcrop in the east bank of the run 0.45 mile in an air line northeast of the junction of Stone Cabin and Rabble Run roads. The section begins at the point where the top of the sandstone crosses the stream N. 24° W. from the top of this ledge, and continues thence up the bed of the run. The latter locality may be found by following the top of the Keefer sandstone from its exposure in the east bank of the run to its outcrop in the field a short distance towards the southeast. A traverse was run from this point at right angles to the strike of the strata across the outcrop of the McKenzie and Wills Creek formations.

This locality affords the most trustworthy measurements of the lower part of the McKenzie formation obtained in the North Mountain region. The measurements of the upper part of the formation are less precise owing to the difficulty in securing accurate strikes and dips.[1]

Section exposed on hill southeast of Lanes Run and northwest of cemetery. Strike and dip used in calculating this part of the section N. 23° E. 40° E., the average of 10 observations.

	Horizontal distance to top of unit Feet	Thickness Beds Feet	Thickness Total Feet
WILLS CREEK FORMATION			
Bloomsburg Member			
Red argillaceous sandstone and arenaceous shale exposed on hilltop.			
MCKENZIE FORMATION			
Fissile, yellowish shale. The top of this unit is 10 feet vertically above base of the McKenzie	492	66	250
Red arenaceous shale	397	12	184
Red, shaly sandstone, making an indistinct ridge on the top of the knob	387	1	172
Red, arenaceous shale. The top of the Keefer sandstone outcrops in the field 358 feet N. 63° W. from the base of this bed	397	83	171
The section is continued by following the base of the red beds of the McKenzie from its outcrop in the east bank of Lanes Run to its outcrop in the field southwest of exposure in bank. This part of the traverse is neglected in horizontal measurements given.			

[1] Measured by tape by C. K. Swartz assisted by G. Taylor.

Traverse N. 75° E. down center of stream[1]

	Horizontal distance to top of unit Feet	Thickness Beds Feet	Thickness Total Feet
Concealed	254	14	88
Dark-gray shale outcropping in ridges crossing stream....	226	36	74
Largely concealed, some beds of dark-gray shale seen in bed of stream	150	33	38
Fissile gray shale exposed in bed of stream	105	5	5
Total thickness of McKenzie formation			300

ROCHESTER FORMATION

Keefer Sandstone Member

Massive conglomeratic sandstone seen on the east bank of the stream S. 24° W. from the base of the preceding unit.

This section like the preceding is remarkable for the great thickness of red beds in the McKenzie, leading Stose to map much of this formation as the Bloomsburg red sandstone in the Pawpaw-Hancock folio of the U. S. Geological Survey.

XV. Section at Hanging Rock

The name Hanging Rock is applied to the massive ledges of the Tuscarora formation exposed in Stone Cabin Gap, at the southern extremity of Sword Mountain, 2½ miles in an air line northwest of Clear Spring. The best exposure of the Rose Hill formation in the North Mountain of Maryland is seen here, affording an almost uninterrupted section of that formation. The thickness of the Rose Hill is much less at this place than it is farther west. There is no satisfactory evidence of faulting and it may be that the reduction in thickness is due to thinning eastward.

The horizontal traverse begins at the base of the Keefer sandstone and extends southeastward along the county road to the top of the Tuscarora sandstone.[2]

[1] Strike and dip employed in calculating the thickness of beds beneath the McKenzie red bed N. 23° E. 40° E., the average of 10 observations.

[2] Measured with tape by C. K. Swartz assisted by G. Taylor. Strike and dip of beds N. 18° E. 61° E., average of 8 observations.

ROCHESTER FORMATION *Keefer Sandstone Member* Traverse S. 45° E.	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Massive conglomeratic sandstone	..	25.0	25.0
ROSE HILL FORMATION			
Concealed. Fissile shale in soil. At the top of this unit were found in loose fragments of sandstone *Cœlospira sulcata, Liocalymmene clintoni* abundant *Calymene niagarensis* var	64.5	48.0	300.5
Ferruginous sandstone loose in soil	65.0	1.0	252.5
Concealed	69.4	3.0	251.5
Hard, gray sandstone rather thin-bedded, stained brown	75.7	4.6	248.5
Concealed. Soil contains fissile gray shale covered with sandstone drift	85.0	7.0	243.9
Bluish ferruginous sandstone	87.7	2.0	236.9
Concealed	99.0	8.8	234.9
Fissile gray shale	100.0	0.8	226.1
Four heavy ledges of blue ferruginous sandstone with interbedded fissile, gray shale in lower part	125.7	20.0	225.3
Fissile, gray, argillaceous shale, a very little, thin-bedded, very argillaceous sandstone. Almost entire unit weathered into soil	184.0	45.4	205.3
Thin-bedded, very argillaceous sandstone	185.0	0.8	159.9
Fissile, gray shale well exposed. Ten feet above bottom of this unit (202 feet horizontally) occur crinoid stems and a few *Cœlospira hemispherica, Calymene* cf. *blumenbachii* var. *macrocephala, Liocalymmene clintoni, Bonnemaia perlonga*	214.0	22.6	159.1
Fissile, gray shale, interbedded with heavier shales and lenticular argillaceous sandstone, breaking irregularly	221.0	5.5	136.5
Interbedded, thin-bedded, hard, argillaceous sandstone and arenaceous shale. A sandstone band 6 inches thick occurs at top of unit	224.0	2.3	131.0
Greenish-gray, arenaceous shale, breaking irregularly	226.0	1.6	128.7
Fissile shale reddish tone	232.0	4.7	127.1
Fissile, gray shale and a very little thin-bedded argillaceous sandstone; 12.5 feet above base of this unit (248 feet horizontally) crinoid stems and *Calymene* sp. occur	264.0	24.9	122.4
Hard, thin-bedded, greenish-gray sandstone with a little interbedded arenaceous shale	269.0	3.9	97.5
Concealed. Soil contains gray sandstone fragments	284.0	11.7	93.6
Interbedded, fissile gray shale and some thin-bedded argillaceous sandstone	323.5	30.7	81.9
Concealed	339.0	12.0	51.2

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Hard, greenish-gray sandstone, becoming thinner-bedded at base	392.0	6.2	39.2
Fissile, gray shale; some thicker and more arenaceous beds	502.0	33.0	33.0
Total thickness of the Rose Hill formation....			300.5

TUSCARORA FORMATION

Very massive, hard, white sandstone ("Hanging Rock").

XVI. Section One Mile Northwest of Clear Spring

This section is exposed on the north side of a millpond situated in the gap south of Johnson Mountain, 1 mile northwest of Clear Spring. The traverse begins at the first exposure of the red strata of the McKenzie formation and extends eastward along the north side of the millpond, to the top of the Tuscarora formation.

The section is thinner than is normal, due probably to faulting. Much of the lower part of the McKenzie has probably been concealed in this manner. Careful search was made for fossils but the strata appear to be barren, contrasting greatly, in this respect, with the richly fossiliferous beds of the Rose Hill formation farther west.[1]

MCKENZIE FORMATION	Horizontal distance from beginning of traverse to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed, red soil on slope.			
Red, very arenaceous shale and argillaceous sandstone, partially covered with soil	27.0	19.6	48.1
Two 4-inch courses of hard, reddish sandstone weathering greenish-gray	27.9	0.6	28.5
Red, argillaceous sandstone, breaking irregularly....	29.0	0.8	27.9
Greenish-gray, argillaceous sandstone, hard	30.4	1.0	27.1
Red, very arenaceous shale, partly concealed	35.0	3.3	26.1
Concealed	54.0	13.8	22.8
Argillaceous sandstone, greenish, micaceous in courses 2 to 8 inches thick	57.2	2.3	9.0
Concealed	66.5	6.7	6.7
Total thickness of the McKenzie formation exposed.			48.2

[1] Measured with tape by C. K. Swartz and G. Taylor.

ROCHESTER FORMATION *Keefer Sandstone Member*	Horizontal distance from beginning of traverse to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
Massive gray sandstone exposed on hillside	68.0	1.1	39.9
Concealed. Soil covered with gray sandstone drift	81.0	9.4	38.8
Massive gray sandstone, stained mottled pink and light brown on surface. Beds 6 inches to 2 feet 6 inches thick	94.2	9.6	29.4
Massive, greenish-gray sandstone partly concealed in upper part, somewhat ferruginous at base. Surface stained brown, lower bed outcrops about 15 feet above on hillside	121.3	19.8	19.8
Thickness of Keefer sandstone			39.9
ROSE HILL FORMATION			
Concealed. Fissile gray shale in soil	128.5	6.6	152.6
Dark-brown, ferruginous sandstone	130.5	1.9	146.0
Concealed. Soil containing fissile gray shale	140.5	9.2	144.1
Hard, greenish, argillaceous sandstone	141.3	0.7	134.9
Fissile, slightly gray arenaceous shale	142.6	1.2	134.2
Hard, greenish, argillaceous sandstone	142.8	0.2	133.0
Fissile gray shale and some interbedded thin-bedded argillaceous sandstone	147.8	4.6	132.8
Dark-red, arenaceous shale, weathers grayish, breaks irregularly	151.3	3.2	128.2
Fissile, gray arenaceous shale with some thin bands of argillaceous sandstone at base	156.5	4.8	125.0
Single course of brown ferruginous sandstone, surface stained by rust	157.1	0.6	120.2
Fissile, gray, arenaceous shale, breaks irregularly; weathers to yellows and browns	165.1	7.4	119.6
Hard, greenish-gray. argillaceous sandstone in two courses	166.8	1.6	112.2
Red, ferruginous shales, break irregularly	168.0	1.1	110.6
Interbedded, fissile gray shale and thin-bedded, greenish-gray argillaceous sandstone	171.0	2.8	109.5
Much weathered, greenish-gray, argillaceous sandstone, medium-bedded	172.0	0.9	106.7
Interbedded, greenish-gray, fissile arenaceous shales and thin-bedded, argillaceous sandstone	179.0	6.5	105.8
Argillaceous sandstone in courses 1 to 4 inches thick, stained brown. Some surfaces marked by trails or fucoids. Base of unit forms projecting ledge	181.5	2.3	99.3
Greenish-gray, arenaceous shale, weathering brown, surface of beds covered with trails or fucoid markings	186.5	4.6	97.0

	Horizontal distance from beginning of traverse to base of beds Feet	Thickness Beds Feet	Total Feet
Very thin-bedded, argillaceous sandstone exposed about 15 feet above on bank	190.5	3.6	92.4
Fissile, gray arenaceous shale breaking into small thin plates	193.5	2.8	88.8
Greenish-gray, arenaceous shale and argillaceous sandstone, breaks irregularly	202.0	7.8	86.0
Interbedded, argillaceous sandstone and a little arenaceous shale, sandstone bands ½ to 2 inches thick, surface marked by trails or fucoids	205.2	3.0	78.2
Largely concealed. Some thick-bedded, arenaceous shale	211.0	5.4	75.2
Arenaceous shale, greenish-gray, marked by trails or fucoids	212.5	1.3	69.8
Interbedded, thin-bedded, argillaceous sandstone and arenaceous shale, greenish-gray, weathering brown; sandstone stained brown	218.0	5.1	68.5
Interbedded, argillaceous sandstone and arenaceous shale. Sandstone heavier-bedded and shale more fissile than in overlying unit. Heavier beds of sandstone at 221, 229 feet. A soft band at 232 feet, and a hard band at 233 feet forming base of unit	233.8	14.6	63.4
Medium-bedded, arenaceous shale, breaking irregularly	239.8	5.5	48.8
Very argillaceous sandstone, stained brown	241.8	1.8	43.3
Concealed	244.8	2.8	41.5
Massive sandstone above arenaceous shale below. Upper sandstone forms a projecting ledge	248.4	2.5	38.7
Massive sandstone	252.0	4.1	36.2
Thin-bedded, argillaceous sandstone and a little arenaceous greenish-gray shale weathering mottled green and brown	254.2	2.0	32.1
Hard sandstone, stained brown	254.9	0.6	30.1
Fissile, gray shale becoming heavier-bedded at base	262.2	6.7	29.5
Concealed	275.0	11.8	22.8
Soft, very argillaceous sandstone, gray, surface stained brown	276.0	0.9	11.0
Concealed	287.0	10.1	10.1
Total thickness of Rose Hill formation			152.7

TUSCARORA FORMATION

Massive sandstone seen a short distance above on hillside and more clearly on opposite side of millpond.

SECTIONS OF THE WILLS CREEK AND TONOLOWAY FORMATIONS

BY

C. K. SWARTZ[1]

A. Sections in Wills Mountain Anticline

I. Section on Keyser-Heddenville Road, Keyser, West Virginia

The Wills Creek and Tonoloway formations are well exposed on the Keyser-Heddenville Road, southeast of Keyser, West Virginia. Although the section is partially concealed, this locality affords an excellent opportunity to measure the thickness of these formations, and to collect their fossils.

The Heddenville road leads eastward from Keyser for a distance of three-fourths of a mile and then turns abruptly to the south. The Helderberg formation is finely exposed along the road south of this point. The Bloomsburg sandstone outcrops in a well-defined ridge which crosses the road nearly half a mile south of this turn.

The section[2] described begins at the base of the Bloomsburg sandstone and extends northward along the road a distance of 1782 feet, terminating at the base of the Helderberg formation.

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Total Feet
HELDERBERG FORMATION			
Massive, nodular limestone	..	123.0	123.0
TONOLOWAY FORMATION			
Road N. 30° E.			
Concealed	1782.0	90.6	588.4
Private road leading northwest.			

[1] The author has been aided in making measurements and collecting fossils by various assistants whose help is acknowledged in appropriate places. The bryozoa and ostracoda have been identified by R. S. Bassler and E. O. Ulrich.

[2] Measured with tape by C. W. Cooke, O. B. Hopkins, and W. A. Price, Jr., under the direction of C. K. Swartz.

Road N. 32° W.	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed	1482.0	71.1	497.8
The strata are concealed along the road from 1249 to 1482 feet of the horizontal traverse. The section described below is exposed in and near a small quarry situated northeast of the road and southeast of a small stream which crosses the road 1322 feet from beginning of section. The horizontal distances here given indicate the points approximately at which the strike of the beds crosses the road.			
Bluish-gray limestone exposed in field, at top of which are found *Rhyncospira globosa*, *Hindella congregata*, *Halliella fissurella*, and *Leperditia alta*	1340.0	16.3	426.7
Dark-colored, thick-bedded limestone N. 49° E. 63° N. W.	1322.0	8.0	410.4
Thin-bedded, dark-blue limestone, lower beds nodular, containing, 4.6 feet above the base of this unit (1306 feet horizontally), *Hindella congregata*, 2.6 feet above the base of this unit occurs ostracods	1313.0	10.6	402.4
Thin-bedded, dark-blue limestone, some beds shaly. Mud cracks occur about the center of this unit. The following fossils occur in a thin bed of arenaceous limestone at the top: *Hindella congregata* and *Leperditia alta*. Nine feet above the base occur (1292 feet horizontally) *Dizygopleura costata*, *D. simulans*, *Leperditia alta*	1301.0	21.3	391.8
Thin-bedded, dark-blue, nodular limestone seen in northeast wall of small quarry. This bed is profusely fossiliferous, containing at the top *Hormatoma rowei*, *H. rowei* var. *nana*, common, *Dizygopleura costata*, *D. simulans*, *Leperditia alta*. Fifteen feet below the top (1276 feet horizontally) occurs *Hindella congregata*. Three feet below the top (1275 feet horizontally) occurs *Hindella congregata* abundant. Eight feet below the top (1269 feet horizontally) occur *Stenochisma ? lamellata*, *Rhynchospira globosa*, *Hindella congregata*, *Hormatoma rowei*	1278.0	10.6	370.0
Thick- and thin-bedded, dark-blue limestone. Some beds marked by mud cracks. The lower beds of this unit are exposed on steep bank east of road	1266.0	14.9	359.9

Road N. 15° E.	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
The section described below is seen along the county road, the uppermost beds being exposed in the steep bank east of the road and southeast of the stream.			
Thin-bedded, platy, argillaceous limestone becoming gray on weathering	1249.0	4.3	345.0
Calcareous shale	..	0.9	340.7
Dark, uneven-bedded, somewhat nodular limestone containing *Stenochisma lamellata*, *Camarotœchia tonolowayensis*, *Hindella congregata*, *Tentaculites gyracanthis* var. *marylandicus*, *Zygobeyrichia ventripunctata*	..	1.8	339.8
Gray, shaly limestone	..	1.0	338 0
Concealed	..	2.5	337.0
Rotten, argillaceous limestone	..	8.0	334.5
Limestone filled with a great profusion of fossils. Partially concealed. This bed constitutes the *Camarotœchia lamellata* zone. In this unit occur *Aulopora* sp., *Favosites* abundant, crinoid rings abundant, Bryozoa, *Schuchertella rugosa* abundant. *Stenochisma lamellata* common, *Camarotœchia litchfieldensis*, *C. tonolowayensis*, *Rhynchospira globosa* abundant, *Tentaculites gyracanthus* var. *marylandicus*. About 326 feet stratigraphically occur *Camarotœchia litchfieldensis*, *Hormatoma rowei* var. *nana*, *Dizygopleura costata*, *D. simulans*, *Zygobeyrichia ventripunctata*, *Z. tonolowayensis*. About 321 feet stratigraphically occur *Dizygopleura costata*, *D. simulans*, *Leperditia alta*	..	9.5	326.5
Concealed	..	2.0	317.0
Dark, compact somewhat crystalline limestone	..	0.5	315.0
Platy limestone weathering gray, some courses argillaceous. Imperfectly exposed	..	8.0	314.5
Impure argillaceous limestone partially concealed	..	0.7	306.5
Concealed	..	1.5	305.8
Crystalline, dark, somewhat irregularly bedded limestone with silicified nodules in lower part. Highly fossiliferous. Near top occur *Hindella congregata*, *Hormatoma* sp. At 302 feet stratigraphically occur *Hindella congregata*, *Dizygopleura costata*, *D. simulans*, *Zygobeyrichia ventripunctata*, *Z. tonolowayensis*. At base occur *Hindella congregata*, *Holopea flintstonensis*, *Leperditia alta*, *Dizygopleura subovalis*, *D. halli*	..	5.0	304.2

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Calcareous shale	..	0.7	299.3
Thin-bedded, platy argillaceous limestone	..	3.5	298.6
Dark crystalline limestone somewhat unevenly bedded and abounding in ostracods. The lower 6 inches contains *Tetrameroceras cumberlandicum* abundant, *Orthoceras* sp., *Hormatoma rowei*. This is the Tetrameroceras zone	..	4.6	295.1
Rotten argillaceous limestone. Purer bands occur at the top and 5 feet below the top. At the top occur *Modiolopsis gregarius, Leperditia alta*	..	1.2	290.5
Compact gray limestone with silicified nodules	..	0.9	289.3
Thin-bedded laminated limestone	..	0.8	288.4
Thick-bedded gray limestone full of solution cavities which are lined with calcite crystals. This bed forms a projecting point on the northwest wall of a small quarry. Its line of strike passes west of a small kiln	..	1.1	287.6
Thin-bedded limestone weathering gray	..	0.5	286.5
Dark-blue crystalline limestone	..	0.4	286.0
Gray laminated limestone	..	0.3	285.6
Calcareous shale below overlain by shaly limestone. The top of the unit consists of shale. Partially concealed	..	25.5	285.3
Thin laminated limestone	..	1.3	259.8
Blue limestone. The lower 1.7 feet thin-bedded, the upper 0.6 feet thick-bedded	..	2.3	258.5
Impure argillaceous limestone with numerous small cavities. Upper 3 feet more compact	..	1.3	256.2
Thin-bedded limestone breaking somewhat irregularly.	..	0.7	254.9
Clay band	..	0.3	254.2
Thin-bedded limestone weathering into plates ¼ to 1 inch thick. Lower courses pink	..	1.3	253.9
Compact, dark-blue, somewhat crystalline limestone. Calcite veins. Hackle teeth on surface	..	3.8	252.6
Rotten, calcareous shale weathering brown	..	0.8	248.8
Compact, somewhat crystalline, dark-blue limestone. Calcite veins	..	3.8	248.0
Compact, granular dark-blue limestone. At top occur *Hindella congregata, Hormatoma rowei* abundant, *Hormatoma* sp.	..	1.2	244.2
Dark, granular limestone. Upper 3 inches shaly, bearing numerous fucoidal markings, lower beds more compact. 2.65 feet above base occur a dimpled			

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
surface on which are found numerous *Hindella congregata* and ostracods. At base occur ostracods....	..	3.3	243.0
Shaly limestone weathering into thin plates, gray color. Beds somewhat undulating................	..	2.2	239.7
Compact blue limestone in a single course, upper surface set with lumps. Containing in upper part *Hindella congregata* and ostracods...............	..	0.6	237.5
Thin-bedded, dark-blue limestone.................	..	1.1	236.9
Shaly limestone with numerous mud cracks forming east wall of quarry.........................	..	2.2	235.8
Compact limestone in a single course...............	..	0.8	233.6
Laminated limestone weathering into beds ½ to 2 inches thick. At 232.5 feet stratigraphically occurs *Leperditia alta*	..	1.6	232.8
Calcareous shale	..	0.3	231.2
Limestone somewhat shaly	..	0.4	230.9
Shaly limestone becoming a calcareous shale above...	..	0.6	230.5
Argillaceous limestone in a single course...........	..	0.4	229.9
Calcareous shale	..	0.2	229.5

Road N. 12° W.

Gray limestone. Upper courses thick-bedded; lower courses somewhat shaly........................	..	8.1	229.3
Thin-bedded limestone weathering gray. About 220 feet stratigraphically *Leperditia alta*.............	..	4.5	221.2
Hard, dark-blue limestone, lower 5 inches forming a single course, remainder thin-bedded. Near base occur (1012 feet horizontally) *Holopea* ? *flintstonensis, Hormatoma rowei* var. *nana, Leperditia alta*.	..	0.8	216.7
Dark-gray limestone weathering in bands a few inches thick, with a massive bed 2 feet thick at top. Mud cracks occur near the top; 14.4 feet below the top of this unit (984 feet horizontally) occurs *Leperditia alta;* 28.5 feet below the top (940 feet horizontally) occurs *Camarotœchia tonolowayensis;* 58 feet below (938 feet horizontally) occurs *Modiolopsis gregarius, Leperditia alta;* 64 feet below the top (925 feet horizontally) occurs *Leperditia alta*..............	1010.0	67.1	215.9
Concealed. Altitude 17 feet below beginning of traverse	929.3	38.6	148.8

Gate leading southeast to an Old Mill and Cabin at 993 Feet Horizontally

Road N. 9½° E.	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed. This unit and the overlying one occupy a slight depression in the hillside.			
Thin-bedded, shaly limestone, partly concealed in the middle of the unit. There are a few bands of thicker-bedded, more massive limestone near the top and bottom	829.0	33.6	89.2
Thick-bedded, dark-blue limestone, weathering thin, beds becoming thinner and somewhat argillaceous at the top; 4.4 feet below the top of this unit (758 feet horizontally) occurs a bed of light gray, arenaceous limestone about 1 foot thick. Thirty-one feet above base of unit (824 feet horizontally) occur *Leperditia alta, Aparchites ? punctillosa, Dizygopleura subovalis, D. halli. Leperditia alta* also occurs at the following altitudes above the base of this unit: 19.2 feet (752 feet horizontally), 0.7 feet (717 feet horizontally)	766.0	26.7	55.7
Medium to thin-bedded, dark-blue limestone, thicker-bedded at bottom. A 4-foot bed of shaly limestone is found 6.5 feet above the base (675 feet horizontally). The top of unit is ripple-marked. *Leperditia alta* occurs 5.5 feet (673 feet horizontally), 0.5 feet (664 feet horizontally) above the base of the unit	716.0	29.0	29.0
Total thickness of the Tonoloway formation			588.4
Entrance to old mill at 663 feet horizontally.			
WILLS CREEK FORMATION			
Concealed in large part. This unit probably consists largely of calcareous shale with some interbedded shaly limestone	663.0	62.0	446.4
Calcareous sandstone	549.0	1.5	384.4
Calcareous shale, with a few argillaceous sandstones. The base of this unit consists of a thin bed of limestone	546.4	47.3	82.9
Road N. 1½° E.			
Mostly concealed. Much shale with occasional outcrops of limestone. Near the top of this unit is a thin-bedded limestone conglomerate. *Leperditia alta* occurs at the following altitudes above the base of this unit: 95.1 feet (292 feet horizontally), 61.9 feet (242 feet horizontally), 31.6 feet (192 feet horizontally) and at top	464.4	208.3	335.6

FIG. 1.—VIEW SHOWING THE WILLS CREEK-MCKENZIE CONTACT.

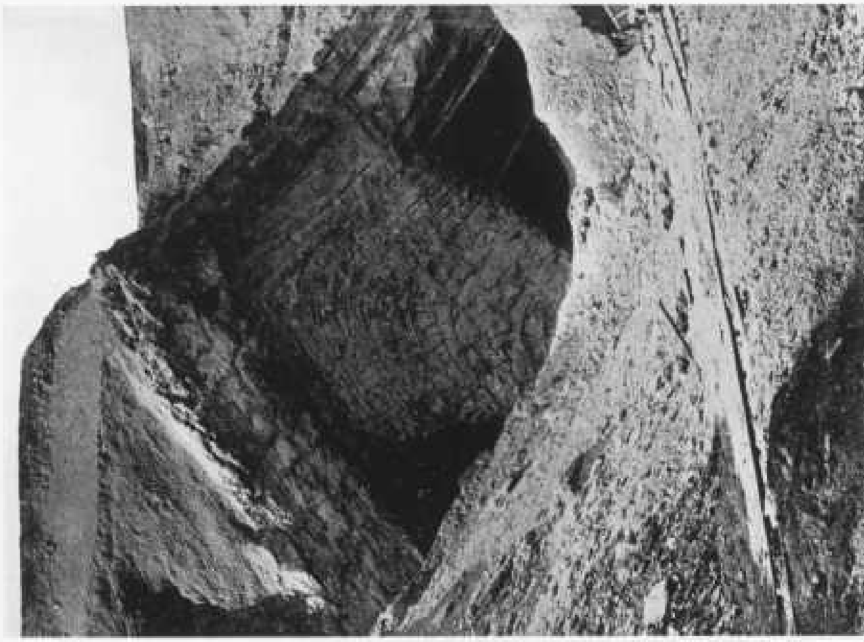

FIG. 2.—VIEW SHOWING THE SALINA FORMATION AT CEMENT MILLS, ALLEGANY COUNTY.

P. 110 B

Road N. 28° W.	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Largely concealed. Calcareous shale with occasional thin beds of limestone. Fossils occur above the base of this unit as follows: 98.4 feet (129 feet horizontally) *Leperditia alta, L. alta breviculata, Bollia nitida, B. immersa, Halliella subequata, Klœdenia normalis, Euklœdenella umbilicata curta, Zygobeyrichia incipiens*: 78.7 feet (107 feet horizontally) *Leperditia alta, Dizygopleura halli*	148.9	100.1	127.3
Bloomsburg Sandstone Member			
Massive sandstone, weathering red, greenish on fresh fracture	30.8	1.5	27.2
Green argillaceous sandstone and arenaceous shale	29.1	2.5	25.7
Arenaceous shale, greenish tone	26.3	2.2	23.2
Thin-bedded, dark-blue limestone	23.8	3.3	21.0
Arenaceous shale, greenish tone, with interbedded beds of argillaceous sandstone. Surface of some beds of sandstone covered with markings resembling trails or impressions of fucoids. *Leperditia alta* occurs 5.4 feet above the base of this unit (16 feet horizontally)	20.1	9.5	17.7
Red, arenaceous shale	9.8	0.7	8.2
Massive sandstone. Upper 1.3 feet deep red, lower part green. This sandstone forms a sharp projecting ledge on the top of the hill. N. 50° E. 60° N. W.	8.8	7.5	7.5
Total thickness of Wills Creek formation			446.4
MCKENZIE FORMATION			
Argillaceous sandstone	..	9.2	..
Greenish arenaceous shale	..	1.5	..
Fissile gray shale, upper beds somewhat arenaceous.			

II. Section on the Baltimore and Ohio Railroad East of Keyser, West Virginia

The Standard Lime and Stone Company has opened extensive quarries on the Baltimore and Ohio Railroad three-fourths of a mile east of Keyser, West Virginia. Two quarries are worked at this place. The western embraces strata extending from the base of the Oriskany to the top of the Tonoloway formation; while the eastern is opened in the Tonoloway.

The eastern section, described below, begins at the Helderberg-Tonoloway contact near the east side of the west quarry and extends eastward through the eastern quarry. The section is continuous with the section of the Helderberg formation described in the volume of the Lower Devonian Deposits of Maryland.[1] This locality presents an excellent exposure of the middle and much of the upper part of the Tonoloway formation.[2]

	Thickness: Beds Feet	Thickness: Total Feet
HELDERBERG FORMATION		
Section exposed in the western quarry. Nodular limestone with some chert containing *Stropheodonta bipartita*, *Whitfieldella minuta*, and ostracods	15.6	15.6
TONOLOWAY FORMATION		
Dark thin-bedded, shaly limestone containing some more compact beds and a band of chert. N. 45° E. 67° N. W. The following fossils were found in this unit. Two feet below the top *Stropheodonta* (*Leptostrophia*) *bipartita* var. *nearpassi*, *Stenochisma ? lamellata* abundant, *Camarotœchia litchfieldensis* abundant, *Spirifer corallinensis* abundant, *Spirifer keyserensis* common, *Tentaculites gyracanthus* var. *marylandicus*, *Calymene camarata* ?. Three feet below the top *Stropheodonta* (*Leptostrophia*) *bipartita* var. *nearpassi* common, *Camarotœchia litchfieldensis* abundant, *Spirifer corallinensis* abundant, *Æchmina dubia*, *Dizygopleura subovalis*. One foot above the base *Spirifer corallinensis*, *Halliella fissurella*, *Dizygopleura costata*, *Aparchites obliquatus*, *Octonaria muricata*, *Zygobeyrichia ventripunctata*, *Z. tonolowayensis*, *Z. virginia*, *Z. ventricornis*, *Dibolbina cristata*, *Bythrocypris phascolinus*, *B. keyserensis*, *Dizygopleura costata*, *D. subovalis*, *D. simulans*, *Leperditia alta*, *Klœdenella bisulcata*	8.0	587.7
East end of west quarry	..	579.7
Largely concealed between the two quarries. This unit consists largely of calcareous shales	90.0	579.7
Calcareous shale and shaly limestone, a few heavier beds of purer limestone	41.0	489.7
Medium to heavy-bedded, dove-colored limestone with thin shale partings	20.0	448.7
Impure, shaly limestone and calcareous shale	4.0	428.7
Thin-bedded, dark-blue limestone	9.0	434.7

[1] Md. Geol. Survey, 1913, p. 560.

[2] Measured with tape by C. W. Cooke, O. B. Hopkins, and W. A. Price, Jr., under the supervision of C. K. Swartz.

	Thickness Beds Feet	Total Feet
Calcareous shale, varying in thickness on strike	2.0	415.7
Dark limestone, heavy-bedded below, thin-bedded above, containing cavities filled with calcite	24.9	413.7
Thin to medium-bedded, dark-colored limestone, containing mud cracks and ripple marks. The base of this unit is formed by a thin bed of fissile, shaly limestone N. 47° E. 70° N. W. *Leperditia alta* occurs 2 feet above the base of this unit	20.0	388.8
Dark, heavy-bedded, fossiliferous limestone. One foot below top occur: *Dizygopleura costata, D. halli, D. simulans, Leperditia alta, Welleria obliqua.* Three feet below the top occur bryozoa abundant, *Hindella congregata* very gibbous, *Orthoceras* sp. small	20.8	368.8
Massive, dark-blue limestone with some bands of shaly limestone. At top occur ostracods and *Hindella congregata*	13.6	350.3
Limestone, very nodular below, less distinctly so above. Two feet above the base of this unit occurs *Camarotœchia litchfieldensis* common, *Rhynchospira globosa* ?, *Hindella congregata, Dizygopleura subovalis, D. simulans, D. halli, Welleria obliqua, Leperditia alta*	10.9	334.4
Fissile, argillaceous limestone at top, massive dark-blue limestone with interbedded shaly limestone below	12.5	323.5
Thin-bedded limestone, containing a great profusion of fossils including *Aulopora* sp., cystid plates common, crinoid rings abundant, bryozoa abundant, *Stropheodonta* sp., *Schuchertella rugosa* abundant, *Stenochisma* ? *lamellata* abundant, *Camarotœchia litchfieldensis* var. *marylandica, Rhynchospira globosa* abundant, *Tentaculites gyracanthus* var. *marylandicus*, crinoid plates	5.2	311.0
Dark-blue, thin-bedded limestone, rick in gastropods. Four feet above the base of this unit occur *Leperditia alta, Welleria obliqua.* Two feet above the base occurs *Favosites* sp., *Hindella congregata, Leperditia alta, Welleria obliqua, Dizygopleura subovalis, D. halli. Leperditia alta* occurs at the bottom	5.8	305.8
Thin-bedded, shaly, fossiliferous limestone with some interbedded, heavier courses, ripple marked. Some strata arenaceous. *Camarotœchia tonolowayensis* occurs at the top. *Camarotœchia litchfieldensis, Rhynchospira globosa, Tentaculites gyracanthus* var. *marylandicus, Calymene camerata* occur 6 feet above the base of the unit	10.0	300.0
Concealed. Approximately	290.0	290.0
Total thickness of the Tonoloway formation		587.7

The following ostracoda are abundant towards the base of the formation: *Welleria obliqua, W. obliqua brevis, W. obliqua longata, Halliella ? triplicata, Dizygopleura halli, D. halli obscura, D. simulans, D. simulans limbata, Bythrocypris phaseolina,* and *Leperditia scalaris præcedens.*

III. Section at Pinto

An excellent section of the Wills Creek and Tonoloway formations is exposed along the tracks of the Baltimore and Ohio Railroad at Pinto, Maryland. The Potomac River traverses the western limb of the Wills Mountain anticline at this point and has made an extensive natural section which has been rendered still more perfect by the construction of the deep cuts of the railway. The strata stand vertical in the cuts and afford an uninterrupted exposure extending from the upper part of the Clinton to the lower beds of the Helderberg. The section of the Wills Creek and Tonoloway formations seen at this locality is not equalled by that found at any other locality in the state.[1]

The section described begins at the bottom of a heavy sandstone which forms the base of the Wills Creek formation and extends thence westward along the railroad tracks, terminating at the Helderberg-Tonoloway contact 90 feet from the center of the road at the western end of the cut.[2]

HELDERBERG FORMATION

Very massive, nodular, fossiliferous limestone.

TONOLOWAY FORMATION	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Laminated, argillaceous limestone	0	3	610	10
Interbedded shaly limestone and calcareous shale	0	11	610	7
Argillaceous limestone, containing *Orbiculoidea* sp., *Camarotœchia litchfieldensis, Dizygopleura costata, Dibolbina cristata, Zygobeyrichia ventripunctata, Z. tonolowayensis*	0	2	609	8

[1] For a discussion of the sections of the McKenzie and Clinton formations at this locality see pages 53-61. The section of the Helderberg here exposed is described in the report on the Lower Devonian, Maryland Geological Survey, pages 141-143.

[2] Measured with tape by C. K. Swartz assisted by R. Leibensperger and G. Taylor.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Thin-bedded blue limestone, bedding somewhat irregular	1	4	606	6
The section is continued in recess north of track.				
Largely concealed. This unit consists chiefly of calcareous shales. The distance from the base of this unit to the Helderberg-Tonoloway contact is 92 feet bearing N. 89° E. Difference in altitude of these points is 6 feet. Average strike and dip N. 14° E. 82° E.	84	4	605	2
Largely concealed. This unit consists chiefly of calcareous shale and argillaceous, shaly limestone. More resistant beds occur at the following distances above base of this unit as follows: 42-44 feet above base bed 2 feet thick, 19 feet 6 inches, bed 9 feet 6 inches, 3 feet to 8 feet 6 inches bed 5 feet 6 inches	44	0	520	6
Argillaceous limestone and calcareous shale	14	0	476	6
Heavy-bedded limestone	2	8	462	6
Argillaceous limestone and calcareous shale	11	7	459	10
Heavy-bedded limestone	2	0	448	3
Laminated limestone	2	0	446	3
Blue limestone	0	8	444	3
Argillaceous limestone and calcareous shale	7	3	443	7
The remainder of the section is continued by railroad track.				
Platy limestone in beds 1 to 6 inches thick	8	0	436	4
Gray limestone mottled with lighter flecks	0	6	428	4
Laminated gray limestone, middle beds massive; thin beds of shale at top	10	8	427	10
Largely concealed. Platy argillaceous limestone and calcareous shale	17	8	417	2
Massive blue limestone	3	3	399	6
Massive calcareous sandstone. This is a limestone containing a large number of rounded quartz grains	1	0	396	3
Shaly limestone, containing solution cavities	1	11	395	3
Gray limestone which breaks irregularly	0	10	393	4
Laminated blue limestone, compact and massive in lower part, upper 2 feet shaly. This unit contains *Leperditia alta*	7	10	392	6
Very massive blue limestone intersected by many calcite seams	3	6	384	8
Laminated limestone, weathers yellow. This unit resembles the underlying one	1	9	381	2
Massive, non-laminated limestone, weathers yellow	5	6	379	5

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Laminated limestone. *Leperditia alta, Welleria obliqua, Dizygopleura costata, D. halli, D. subovalis* occur at about 873 feet	2	7	373	11
Blue limestone with many crystal bands. The upper part is heavy-bedded. At the top of this unit are found *Camarotœchia litchfieldensis* abundant, *Hindella congregata* abundant, *Hormatoma rowei, Halliella fissurella, Dizygopleura costata, D. simulans, Zygobeyrichia ventripunctata.* Three feet 3 inches above the base of this unit are found *Camarotœchia litchfieldensis* common, *C. tonolowayensis, Hindella congregata, Halliella fissurella, Dizygopleura costata, D. simulans, Zygobeyrichia ventripunctata, Z. tonolowayensis*	6	5	371	4
Single course of compact, blue crystalline limestone	1	0	364	11
Calcareous shale and shaly limestone	5	5	363	11
Laminated limestone in lower part, courses 3 to 12 inches thick. Middle thin-bedded shale. Upper heavier-bedded. At bottom of this unit occurs *Hindella congregata*	3	11	358	6
Rotten limestone	2	6	354	7
Dark-gray limestone, weathers light-gray	1	9	352	1
Rather thick-bedded, laminated limestone. This limestone forms a low pinnacle	13	7	350	4
Thick-bedded magnesian limestone. Single course below, the upper 4 inches being a separate course	2	3	336	9
Calcareous shale and shaly limestone	0	11	334	6
Limestone, lower part laminated, upper part magnesian	1	6	333	7
Gray limestone, breaks irregularly. The upper 6 inches are somewhat laminated. This unit is in a depression	1	5	332	1
Laminated limestone. Upper bed 3 to 12 inches thick. At 324 feet stratigraphically occur *Dizygopleura subovalis, D. simulans, Leperditia alta, Welleria obliqua. Aparchites punctillosa.* At 322 feet stratigraphically occur *Halliella fissurella, Dizygopleura costata, Octonaria muricata*	10	0	330	8
Gray limestone with numerous crystalline bands, somewhat irregularly bedded, the beds being 3 to 12 inches thick. This unit contains numerous fossiliferous bands bearing *Halliella fissurella, Dizygopleura costata, D. simulans, Octonaria muricata, Bolbina cristata, Zygobeyrichia ventripunctata, Z. tonolowayensis,* bryozoa, *Camarotœchia litchfieldensis* abundant, *Hindella congregata, Tentaculites gyracanthus* var. *marylandicus* abundant	9	6	320	8

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Compact gray limestone with beds 1 to 4 inches thick.	1	3	311	2
Compact limestone containing large chert nodules....	0	7	309	11
Banded, light-colored limestone.....................	0	7	309	4
Rotten, magnesian limestone, breaks irregularly. The lower part is heavy-bedded.......................	1	0	308	9
Interbedded calcareous shales and laminated argillaceous limestone. The upper is largely shale........	3	6	307	9
Calcareous shale and shaly limestone profusely fossiliferous containing near top cystid plates, bryozoa abundant, *Schuchertella rugosa*, *Camarotœchia litchfieldensis* abundant, *Rhynchospira globosa* abundant, *Hindella congregata*, *Halliella fissurella*, *Dizygopleura costata*, *D. halli*, *D. simulans*, *D. subovalis*, *Zygobeyrichia ventripunctata*, *Z. tonolowayensis*, *Leperditia alta*, *Aparchites punctillosa*, *Welleria obliqua*	3	0	301	6
Shaly crystalline limestone very fossiliferous containing bryozoa, *Schuchertella rugosa*, abundant, *Camarotœchia tonolowoyensis*, *Rhynchospira globosa* abundant, *Hindella congregata*, *Halliella fissurella*, *Dizygopleura costata*, *D. simulans*, *Octonaria muricata*, *Dibolbina cristata*, *Zygobeyrichia ventripunctata*, *Z. tonolowoyensis*	0	4	298	6
Blue crystalline limestone, beds somewhat irregular. About 296 feet ostracods *Dizygopleura halli* and *Leperditia alta*	4	10	298	2
Calcareous shale	0	7	293	4
Blue limestone with somewhat irregular bedding, breaking into layers from 1 to several inches in thickness. This limestone forms a pinnacle. Fossils are found above the base of this unit as follows: 5½ feet *Camarotœchia litchfieldensis* common, *Rhynchospira globosa* common, *Hindella congregata* common, *Loxonema* ? sp., *Leperditia alta*, *Dizygopleura subovalis*, *D. halli*. Four and one-half feet above base: *Hindella congregata*, *Hormatoma rowei*, *Leperditia alta*, *Welleria obliqua*, *Dizygopleura subovalia*, *D. halli*. Two feet: *Modiolopsis gregarius* abundant, *Hormatoma rowei* abundant. Near base: *Camarotœchia litchfieldensis* common, *Rhynchospira globosa* common, *Hindella congregata* common, *Loxonoma* ? sp.	9	0	292	9

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Rotten limestone, crevice below filled with clay.......	1	0	283	9
Thin-bedded, blue limestone. The beds are somewhat irregular. Fossils occur at the following distances above base: About 13 feet *Camarotœchia litchfieldensis, Leperditia alta, Dizygopleura subovalia, D. halli, D. simulans.* About 8 feet *Leperditia alta, Welleria obliqua, Dizygopleura subovalia, D. halli.* Four feet: *Leperditia alta, Welleria obliqua, Dizygopleura subovalia, D. halli.* Near base: *Camarotœchia litchfieldensis, Tentaculites gyracanthus* var. *marylandicus, Leperditia alta, Aparchites punctillosa, Dizygopleura subovalis, D. halli, Welleria obliqua*.......	14	6	282	9
Laminated limestone. *Dizygopleura halli*............	1	7	268	3
Cavity filled with debris...........................	3	5	266	8
Laminated blue limestone. In the middle of this unit is a cavern filled with horizontal layers of travertine. This middle part forms a pinnacle. At about 249 feet occurs *Hindella congregata*...............	31	6	293	3
Crevice filled with travertine and debris..............	2	1	231	9
Impure, argillaceous limestone. Solution cavities are found in the upper foot. Ten inches above base are found *Hindella congregata, Leperditia alta, Aparchites punctillosa*..............................	1	3	229	8
Compact blue limestone in beds 6 to 8 inches thick....	5	6	228	5
Laminated blue limestone. Lower beds are 1 inch thick, heavier-bedded above. Fossils zones, which are best seen far up the slope, occur at the following distances above the base of this unit: 7½ feet: *Hindella congregata, Leperditia alta;* 5 feet 4 inches: *Hindella congregata* abundant, *Hormatoma rowei* var. *nana, Dizygopleura halli, D. simulans, Leperditia alta, Aparchites puntillosa, Welleria obliqua;* 4 feet 11 inches: *Hindella congregata* abundant; 3 feet: *Hindella congregata* abundant, *Leperditia alta;* 1½ feet *Hindella congregata* abundant, *Loxonema* ? sp., *Leperditia alta;* 11 inches: *Hindella congregata, Hormatoma rowei* var. *nana* abundant; *Leperditia alta;* 7 inches *Hindella congregata, Hormatoma rowei* var. *nana, Leperditia alta*.........................	9	6	222	11
Compact, dark blue, crystalline limestone forming the center of a prominent pinnacle. This unit contains *Hindella congregata, Hormatoma rowei* var. *nana, Leperditia alta*................................	0	7	213	5
Somewhat unevenly-bedded, platy limestone breaking into beds 1 to 2 inches thick. The lower 18 inches				

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
are more massive, crystalline and fossiliferous. One foot above base occur *Spirifer vanuxemi*, *S. vanuxemi* var. *tonolowayensis* ?, and *Hindella congregata*. In middle occurs *Leperditia alta*	5	6	212	10
Calcareous shale	0	8	207	4
Laminated blue limestone carrying in lower 5 feet *Leperditia alta*	16	0	206	8
Dark, argillaceous limestone, beds about 1 inch thick. This unit occupies the center of a depression. At top occur *Leperditia alta*, *Dizygopleura halli*, *Kyammoides swartzi;* at base occur *Hindella congregata*, *Leperditia alta*, *Welleria obliqua*, *Dizygopleura halli*.	4	3	190	8
Thin-bedded, platy limestone, weathering into beds ½ to 1 inch thick. Three courses heavier-bedded. Three feet 3 inches above base of this unit is a spike in the wall opposite section post 20-30	13	3	186	5
Blue limestone. Lower beds ½ to 1 inch thick, upper 7 feet massive, forming a pinnacle. Ten feet above base occur *Camarotœchia tonolowayensis*, *Modiolopsis leightoni* ?, *Leperditia alta*. At 6 feet *Camarotœchia tonolowayensis*. *Leperditia alta* occurs near top and 7 to 9 feet above base	28	8	173	2
Rotten limestone	0	10	144	6
Thin-bedded, blue, argillaceous limestone. The upper 16 inches are heavier-bedded	6	8	143	8
Shaly limestone approaching calcareous shale. Contains *Leperditia alta*	8	2	137	0
Impure argillaceous limestone, weathering yellow. This unit contains numerous solution cavities and a sandstone lens 18 inches below the top	8	0	128	10
Platy blue limestone	1	11	120	10
Calcareous shale containing *Leperditia alta*	6	2	118	11
Gray limestone, beds somewhat undulating	1	0	112	9
Calcareous shale and shaly limestone weathering yellow. This unit is depressed below general level *Leperditia alta* occurs 18 to 22 feet above base	30	4	109	11
Platy blue limestone in beds ½ to 2 inches thick containing *Leperditia alta*	6	8	81	5
Dark-gray limestone. Top and bottom of unit compact, middle thin-bedded and shaly. Four feet 9 inches above base occur *Dizygopleura simulans*, *D. halli*, *Leperditia alta*. One foot above base is *Leperditia alta*	8	1	74	9
Calcareous shale with some bands of limestone near base	5	4	66	8

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Compact, dark-gray oölitic limestone	1	0	61	4
Calcareous shale	0	6	60	4
Platy limestone, becoming quite shaly near top	10	8	59	10
Single bed of magnesian limestone, weathers light-colored	0	11	49	2
Platy blue limestone	4	2	48	3
Compact gray limestone in bed 2 to 4 inches thick	3	4	44	1
Limestone, shaly below, thicker-bedded above. Upper part weathers yellowish	1	10	40	9
Massive gray limestone	2	9	38	11
Platy limestone, weathers slightly yellow	1	9	36	2
Dark, shaly limestone, breaking into thin plates on weathering	3	6	34	5
Hard, laminated, blue limestone. The lower 2 feet are weathered to form a depression. The upper 18 inches are more compact and resistant, forming the middle of a high pinnacle on the west face of which are lumps suggesting *Stromatopora* and carrying *Leperditia scalaris præcedens, Aparchites punctillosa, Wellcria obliqua, Dizygopleura subovalia, D. halli obscura, D. simulans, D. simulans limbata*	10	11	30	11
Hard, compact, platy limestone	3	4	20	0
Argillaceous limestone weathering into thin beds	0	9	16	8
Compact, gray limestone. Beds 2 to 10 inches thick	2	3	15	1
Calcareous shale	4	2	13	8
Very massive, dark-blue, lenticular limestone very resistant. Faulted at this point. Thickness varies from 5 feet 5 inches below to 9 feet 6 inches above	9	6	9	6
Total thickness of the Tonoloway formation			610	10

WILLS CREEK FORMATION

Fissile gray, calcareous shale and shaly limestone. The lower 8 inches are more compact	7	6	459	4
Calcareous shale and fissile limestone, forming a depression. Lower part rotten. Imprints of cubical crystals, probably salt crystals, 18 inches above base	2	7	451	10
Compact, hard gray limestone containing *Leperditia alta*	1	11	449	3
Laminated limestone with a little shale. Much of the shale weathers to thin, fissile plates	9	0	447	4
Laminated argillaceous limestone, intersected by numerous calcite seams at right angles to the bedding. This unit forms a depression on weathering	2	8	438	4

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Compact, gray limestone	1	7	435	8
Dark, calcareous shale	0	6	434	1
Laminated limestone and calcareous shale	11	5	433	7
Dark, calcareous shale. Occupies a depression	0	11	422	2
Thin-bedded, laminated limestone with some argillaceous shale. East side of the section house is 13 feet 3 inches above base of this unit. Impressions of cubical crystals probably of salt occur 17 feet 5 inches above base of this unit	18	6	421	3
Impure limestone full of solution cavities	0	7	402	9
Argillaceous limestone beds, 1 to 3 inches thick	0	9	402	2
Dark shale	1	4	401	5
Thin-bedded limestone with a little shale	2	5	397	8
Arenaceous shale	3	8	397	8
Argillaceous shaly limestone, somewhat arenaceous in places and interbedded shale	2	5	394	0
Fissile black shale	1	18	391	7
Thin-bedded, argillaceous and calcareous shale. This unit is much folded	7	0	389	11
Siliceous limestone with some interbedded limestone. Beds 2 to 4 inches thick	2	11	382	11
Dark, fissile shale	0	4	380	0
Sandstone	2	0	379	8
Calcareous mud rock	2	11	377	8
Magnesian limestone, breaks irregularly	0	5	374	9
Mud rock, lower part shaly	5	9	374	4
Massive, thick-bedded calcareous shale, approaching a limestone. *Leperditia alta* occurs about 2 feet below top	6	11	368	7
Black shale	0	4	361	8
Mud rock, upper 3 feet 3 inches somewhat laminated	9	3	361	4
Banded limestone, weathers yellow	2	1	352	1
Mud rock. This unit is penetrated 2½ feet above the base by a number of very thin seams containing *Leperditia alta*	10	3	350	0
Massive limestone, weathers yellowish. Upper 6 inches are banded, containing *Leperditia alta*, *L. alta brevicula*, *Klœdenia normalis* var., *Euklœdenella punctillosa*	2	1	339	7
Fissile, black shale	0	4	337	6
Compact, impure limestone, weathers with a yellowish tone	0	9	337	2
Dark, fissile shale	1	7	336	5
Laminated argillaceous limestone and interbedded calcareous shale. The limestone weathers yellow	4	2	334	10

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Mud rock, weathers green	4	0	330	8
Rotten limestone, breaks irregularly	0	11	336	8
Mud rock. This unit contains numerous cavities filled with calcite	18	2	325	9
Clay seam	1	10	307	7
Mud rock, weathers green	5	1	305	9
Laminated limestone with some interbedded shale, weathers yellow. Dark shale 7 inches thick at base.	3	10	300	8
Laminated argillaceous limestone, somewhat arenaceous at top. The lower 2.5 feet are rotten and yellow	5	0	296	10
Argillaceous sandstone	0	7	291	10
Impure magnesian limestone	0	10	291	3
Thin-bedded, argillaceous limestone and calcareous shale. Shaly below, thick-bedded above. A rotten band occurs 2 feet above the base	5	9	290	5
Impure limestone	0	9	284	8
Calcareous mud rock containing *Leperditia alta*	5	0	283	11
Impure argillaceous limestone, breaks irregularly there being no lamination	1	6	278	11
Calcareous shale, dark and fissile below, thicker above.	3	7	277	5
Impure limestone. Upper part of the unit is rotten yellow. Lower part contains *Leperditia alta*	1	1	273	10
Sandstone	0	4	272	9
Mud rock	0	9	272	5
Laminated calcareous shale	1	2	271	8
Thin-bedded, laminated limestone with some calcareous shale. The limestone weathers yellow	1	4	270	6
Rotten limestone, weathers brown, containing *Leperditia alta*	0	9	269	2
Banded limestone. Beds 1 to 4 inches thick, weathers yellow	1	5	268	5
Dark, fissile shale with several thin bands of limestone, containing *Leperditia alta*	1	1	267	0
Arenaceous shale containing numerous bands of sand, weathers to a greenish tone	2	7	265	11
Laminated limestone with some interbedded calcareous shale. The limestone weathers yellow	2	6	263	4
Interbedded shale and argillaceous limestone	1	8	260	10
Mud rock	3	6	259	2
Argillaceous sandstone, weathers green	0	4	255	8
Laminated limestone, weathering into thin sheets with some interbedded shale. The lower part is rotten. This unit turns yellow on weathering	4	10	255	4
Mud rock, weathering green	1	8	250	6

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Fissile, calcareous shale, greenish above dark below, containing some bands of impure platy limestone...	4	10	248	10
Mud rock	1	4	244	0
Magnesian limestone, breaks irregularly, weathers yellow	1	7	242	8
Fissile, calcareous shale. Mud cracks on the surfaces.	7	0	241	1
Mud seam	1	6	234	1
Dark compact limestone. The upper 10 inches are medium to thin-bedded, the next 20 inches are massive; the next 14 inches thin-bedded. The lower bed, 1 foot thick, contains *Camarotœchia litchfieldensis* and *Spirifer vanuxemi*	4	8	232	7
Thick-bedded, argillaceous limestone, weathers to a yellowish tone; upper part of unit shaly..............	1	11	227	11
Mud rock, weathers to a greenish tone...............	1	4	226	0
Laminated argillaceous limestone, the lower 6 inches shaly	1	9	224	8
Calcareous mud rock. *Leperditia alta* is found in lower 3 feet	7	1	222	11
Argillaceous limestone in two courses separated by dark, fissile shale. *Leperditia alta* occurs at top....	1	4	215	10
Banded, argillaceous limestone, weathers yellow......	1	8	214	6
Calcareous mud rock, weathering to a greenish tone..	9	2	212	10
Laminated calcareous shale, rather thick-bedded......	1	8	203	8
Thin-bedded, argillaceous limestone..................	2	4	202	0
Thin-bedded, argillaceous limestone with some calcareous shale. The shale weathers yellow............	3	9	199	8
Calcareous mud rock, upper part weathers greenish. The lower part is dark colored and more fissile.....	6	6	195	11
Dark, fissile, calcareous shale with some argillaceous limestone bands. A compact band of limestone 6 to 8 inches thick at the top of the unit contains *Leperditia alta*	7	8	189	5
Dark, compact limestone containing *Leperditia alta* at base	1	7	181	9
Calcareous mud rock, breaks irregularly and weathers to a greenish tone. A band of fissile shale 2 inches thick forms the top of the unit..................	2	0	180	2
Calcareous shale, lower part laminated. Upper part thicker-bedded. A 1-inch band of limestone at top..	0	10	178	2
Dark, fissile calcareous shale, surfaces covered with mud cracks; some thin limestone bands at the top of the unit. The top of this unit forms the west wall of the cement tunnel	2	3	177	4

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Laminated, argillaceous limestone with some interbedded shale. The beds vary from 1 to several inches in thickness and turn yellow on weathering........	4	0	175	1
Fissile, black, calcareous shale, covered with mud cracks. *Leperditia elongata willsensis* present......	4	8	171	1
Hard, dark-brown limestone in course 3 to 6 inches thick. At the track level an artificial wall is seen. At base occur *Leperditia alta brevicula, Klœdenia normalis appressa*	1	6	166	5
Fissile, black calcareous shale covered with mud cracks. A few thin bands of argillaceous limestone.	8	8	164	11
Thin-bedded, gray limestone. The middle foot of the unit is very argillaceous and weathers into beds ½ to 1 inch thick. The top of this unit forms the east wall of the cement tunnel....................	3	0	156	3
Fissile, black calcareous shale with a few thin layers of laminated limestone, stained yellow............	3	4	153	3
Laminated argillaceous limestone stained yellow......	3	1	149	11
Mud rock, breaking irregularly, weathers greenish, containing *Leperditia alta*	1	11	146	10
Impure laminated limestone, stained yellow and some calcareous shale	0	11	144	11
Thin-bedded, laminated, calcareous shale with a few beds of argillaceous limestone. Much of the shale is nearly black, a few layers, however, a yellowish tone. Mud cracks cover the surface of the shale. The cement tunnel is in the upper part of this unit......	14	10	140	0
Alternating beds of dark shale and thin-bedded argillaceous limestone with *Bollia pulchella*............	5	1	129	2
Platy limestone with some interbedded calcareous shale	2	5	124	1
Dark, crinkled shale	0	8	121	8
Interbedded, calcareous shale, and thin-bedded limestone in beds ¼ to 6 inches thick. The thickness assigned to this unit may be excessive on account of much intricate, minor folding..................	15	0	121	0
Laminated argillaceous limestone, weathers yellow...	2	0	106	0
Fissile, calcareous shale, purplish tone............	2	5	104	0
Very argillaceous, impure limestone.................	1	0	101	7
Thin-bedded, calcareous shale	1	9	100	7
Thick-bedded, calcareous mud rock..................	6	2	98	10
Dark, calcareous shale with two bands of impure argillaceous limestone in the upper part. This unit is thicker-bedded than the underlying unit...........	4	0	92	8

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Fissile, dark, calcareous shale with numerous mud cracks	4	0	88	8
Fissile, calcareous shale, covered with mud cracks. A 3-inch band of limestone at top. The base of this unit forms west wall of cement tunnel	1	5	84	8
Fissile, laminated shale, and thin-bedded argillaceous limestone. Surfaces of shale layers covered with mud cracks	16	0	83	3
Thick-bedded, calcareous shale and impure argillaceous limestone	1	6	67	3
Laminated calcareous shale, with a thick bed of calcareous mud rock in the middle. This unit is seen in the roof of the cement tunnel	4	0	65	9
Laminated calcareous shale with surfaces covered with mud cracks. The top of this bed forms the east wall of the cement tunnel	0	8	61	9
Thick-bedded, calcareous mud rock, weathering yellow.	3	1	61	1
Laminated shale	0	6	58	0
Thick-bedded argillaceous limestone. Upper 2 feet banded	4	3	57	6
Calcareous mud rock containing, at the top, *Leperditia alta*	4	1	53	3
Interbedded calcareous shale and bands of limestone ½ to 1 inch thick. Ten inches above the base of this unit occur *Leperditia alta*	1	7	49	2
Dark-blue limestone. Thin band of shale 6 inches below top. The upper part is oölitic. At the base occurs *Leperditia alta*. At top occurs *Leperditia elongata willsensis*	1	7	47	7
Calcareous mud rock, weathering into irregular fragments, containing *Leperditia alta, Bollia immersa, B. nitida, Zygobeyrichia incipiens, Z. ventricornis. Halliella subequata, Klœdenia normalis, Euklœdenella umblicata curta, Bythocypris pergracillis*	4	0	46	0
Impure calcareous shale. Upper part thick-bedded. Surfaces of many of the beds covered with mud cracks. The top of this unit is seen on sighting along the east face of the upper box at the base of the signal post marked E 187-45. In lower 2 feet occurs *Leperditia alta*	4	0	42	0
Fissile, drab, calcareous shale with interbedded platy, argillaceous limestone in bands 1 to 3 inches thick. Three feet 6 inches above the base of this unit occurs *Leperditia alta* and *Actinopteria* sp	6	0	38	0

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Arenaceous, calcareous shale. Some thin bands of limestone ¼ to 2 inches in thickness 4 feet below the top. Beds variegated in color, some drab, some greenish	1	4	32	0
Bloomsburg Sandstone Member				
Greenish, arenaceous shale, overlain by argillaceous sandstone with mud cracks on surface of the shale. Indistinct worm borings occur in the shale parallel to the bedding. About 1 foot above the base occurs *Leperditia alta*	1	8	20	8
Single course of massive, reddish-brown, highly ferruginous sandstone	2	0	19	0
Arenaceous shale penetrated by worm borings ½ inch in diameter placed at right angles to the bedding planes	1	0	17	0
Platy argillaceous limestone with some interbedded shale. A bed of sandstone 14 inches thick 3 feet 6 inches above the base. Middle beds are disintegrated and appear as ferruginous clay, containing *Leperditia alta* in lower three feet. *The Cedar Cliff sandstone*	8	0	16	0
Massive, fine-grained sandstone of greenish-yellow tone.	8	0	8	0
Total thickness of Wills Creek formation			459	4
McKENZIE FORMATION				
Thin-bedded, greenish argillaceous sandstone with some interbedded shale. Lower 6 inches quite shaly	3	11	..	..
Dark, fissile, arenaceous shale interbedded with a few beds of greenish sandstone. The shale contains worm borings similar to those in the underlying unit	2	3	..	..
Dark-gray shale, nearly black when fresh. A few thin sandstone films occur in this unit becoming conspicuous toward the top. Worm borings 1 mm. in diameter penetrate the unit parallel to the bedding plane, some of which radiate from a center yielding stellate forms, others seem to branch	4	1	..	..
Fissile, dark-gray shale. The worm borings occur chiefly in the upper part and resemble those in the overlying unit	3	3	..	..
Fissile, drab shale, interbedded with thin beds of limestone.				

FIG. 1.—VIEW SHOWING FOLDING OF THE SILURIAN ON GREAT CACAPON RIVER.

FIG. 2.—DETAIL OF A PART OF FIG. 1.

IV. Section at Cedar Cliff, West Virginia

An excellent section of the upper part of the Wills Creek formation is exposed on the Western Maryland Railway at Cedar Cliff, West Virginia, 4 miles southwest of Cumberland. The Potomac River, which flows at the base of the Knobly Mountain has cut the western slope of the mountain into a lofty and abrupt escarpment which rises shear from the river, leaving only room for the railroad at places between the river and the cliff. The section described begins 360 feet north of the northern wall of the cement mill and is measured along the Western Maryland Railway. It terminates 1400 feet northeast of the railroad station and 400 feet south of the ravine, at the base of a very massive ledge of limestone. The upper beds are described from exposures in and about the cement tunnels high above the level of the tracks, although these strata also outcrop at the level of the tracks.

This locality is of unusual interest because it has afforded finely preserved Eurypterids. The latter are found in a cream-colored, laminated calcareous rock, which outcrops a few feet above the level of the tracks, northeast of the cement mill.[1]

	Thickness			
	Beds		Total	
TONOLOWAY FORMATION	Feet	Inches	Feet	Inches
Very massive, dark bluish-gray limestone. This bed is seen on the railroad track and also forms the roof of the cement tunnel above the cement mill.........	7	0	..	..
WILLS CREEK FORMATION				
The following section is seen in the cement tunnels. The same strata are exposed along the railroad tracks farther north:				
Medium to thin-bedded, gray, argillaceous limestone, weathering to yellow. The upper part is laminated.	6	2	460	8
Rotten, buff, calcareous mud rock, somewhat banded. The bottom of this unit is at the level of the bottom of the cement tunnel..............................	3	0	454	6
Impure, argillaceous limestone, breaking irregularly..	0	11	451	6

[1] Measured by R. Leibensperger under the direction of C. K. Swartz. Thickness of units measured directly.

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
Blue argillaceous limestone, breaking into plates. The character of the material changes as the bed is followed down toward the level of the railroad tracks, where it becomes yellow due to weathering. This bed constitutes the eurypterid zone and contains *Dolichopterus cumberlandicus*	1	6	450	7
Arenaceous limestone forming a single course	0	6	449	1
Soft, gray clay	1	0	448	7
Medium to thin-bedded gray, argillaceous limestone, weathering yellow. Lower 18 inches very thin-bedded	4	6	447	7
Top and bottom of this unit yellow, travertine-like, middle banded buff, mud rock. The bottom of unit is the top of a cement tunnel	4	0	441	1
Black, crinkly shaly limestone; seen near roof of cave.	1	0	437	1
Medium-bedded, argillaceous limestone. Beds vary in color from dark-gray to yellow. A band of fissile, black shale 3 inches thick 6 feet below the top on unit	8	6	436	1
The section is continued along the railroad track north of the cement mill.				
Medium-bedded, dark-blue limestone. The top of this unit forms the bottom of the cement tunnel	2	6	427	7
Dark, calcareous shale breaking into very thin, flat plates	1	8	425	1
Mud rock. Lower part brown and fairly thick-bedded, upper part thinner-bedded, dark-gray and somewhat like the overlying unit	2	0	423	5
Blue, arenaceous shale, weathering yellow and breaking into long thin plates	1	9	421	5
Dark-blue, medium-bedded, argillaceous limestone, becoming yellow above	3	0	419	8
Black shale breaking into very thin plates	3	0	416	8
Dark-blue, thin-bedded, argillaceous limestone	5	0	413	8
Black shale becoming brown and soft above	4	0	408	8
Medium to thin-bedded, dark-blue limestone with some interbedded shale	12	0	404	8
Dark-blue calcareous shale	2	4	392	8
Medium to thin-bedded, dark-blue limestone	10	0	390	4
Dark, calcareous shale	1	6	380	4
Argillaceous limestone	1	0	378	10
Sandstone	0	11	377	10
Dark-gray, calcareous shale	3	3	376	9
Dark-blue, argillaceous limestone, consisting of a single course	0	6	373	6

	Thickness: Beds, Feet	Beds, Inches	Total, Feet	Total, Inches
Very fissile, dark-blue shale	6	0	373	0
Blue, argillaceous limestone, breaking irregularly. Upper part heavy-bedded; lower part thinner-bedded	7	0	367	0
Concealed to base of formation. Approximately	360	0	360	0
Approximate thickness of Wills Creek formation			460	8

V. Section at Cedar Cliff, Maryland

A section embracing the lower beds of the Wills Creek formation and the upper part of the McKenzie formation is exposed in the cut of the Baltimore and Ohio Railroad at Cedar Cliff, Maryland, 4 miles southwest of Cumberland. The measurements begin at the center of a small syncline about 900 feet southwest of the railroad station and extend thence westward along the railroad track. The beds are cut by several small faults.

This locality affords an excellent exposure of the Bloomsburg member of the Wills Creek formation and of the Wills Creek-McKenzie contact. An interesting feature is the occurrence within the Bloomsburg member of a thick bed of limestone which is named from this locality the Cedar Cliff limestone. It is manifestly the same bed as that which has been so much weathered at Pinto as to form the "disintegrated rock" at the latter locality. This limestone occurs constantly in the Bloomsburg member as far east as the vicinity of Hancock, where its thickness is reduced to a few inches. It has not been observed east of this latter locality.[1]

WILLS CREEK FORMATION	Thickness: Beds, Feet	Total, Feet
Concealed.		
Axis of syncline. Thin-bedded limestone and calcareous shale, the former predominating at top and bottom, the latter in the middle. This unit contains numerous ostracods near the base. *Leperditia alta* occurs 15 feet above the base of unit	23.0	88.8
Massive, greenish-gray limestone, weathering yellow, making a distinct band	2.5	65.8
Light-gray, heavy-bedded, calcareous shale with a few bands of blue limestone near the base. The limestone bands contain *Leperditia alta, Halliella subequata, Klœdenia normalis*	4.7	57.8

[1] Measured with tape by W. A. Price, Jr.

	Thickness Beds Feet	Total Feet
Heavy-bedded, dark-blue, fossiliferous limestone, becoming reddish on weathering. *Leperditia alta* occurs at about 1.2 feet above the base of unit	2.3	53.1
Light-gray, calcareous shale, thick-bedded, weathering into irregular fragments	7.2	50.8
Thin-bedded, calcareous shale	7.0	43.6
Hard blue limestone, containing *Leperditia alta* near base	1.6	42.9
Gray limestone with two thin bands of sandstone near top	5.9	41.3
Thick-bedded, calcareous shale, reddish tone	1.0	35.4
Thick-bedded, calcareous shale with a band of sandstone 3 inches thick below middle	7.3	34.4
Bloomsburg Member		
Massive, brownish-red sandstone	2.0	23.2
Cedar Cliff limestone consisting of:		
Thin-bedded limestone and dark calcareous shale with a few thin beds of sandstone	3.3	21.2
Thick-bedded, bluish-gray, arenaceous limestone. *Leperditia alta* occurs about 6 feet above the base of unit	4.5	17.9
Spring.		
Light-gray calcareous shale and thin-bedded calcareous sandstone containing *Leperditia alta* near base	1.9	13.4
Thin-bedded, dark-gray calcareous sandstone containing numerous *Leperditia alta* at base	0.5	11.5
Light-gray arenaceous limestone conglomerate, consisting of hard siliceous nodules in a softer matrix	3.0	11.0
Massive, red sandstone	3.0	18.0
Gray sandstone with some shale partings	5.0	5.0
Total thickness Wills Creek formation exposed		88.8
McKENZIE FORMATION [1]		
Dark, mottled shale, 6.5 feet above base is a band of limestone containing abundant but poorly preserved worm borings	13.5	..
Light-gray and bluish sandstone	3.0	..

VI. Section on Wills Creek, Cumberland

The Wills Creek formation receives its name from former exposures of its strata in the south bank of Wills Creek in the city of Cumberland where a cement quarry was operated a short distance east of Wills Mountain. Extensive openings were made at this point for the purpose of

[1] The section of the McKenzie formation exposed here is described on page 61 of this volume.

mining certain beds of the formation which were burned into natural cement. The work is abandoned at the present time so that the tunnels are no longer accessible and the banks of the opening have become largely covered. The section is less perfectly exposed than it was formerly and is hence not so well adapted for study as that at Pinto.

The following section begins at the base of the Bloomsburg member on the west side of the old quarry opening and continues eastward in the opening and in the cliff in the rear of the cement mill.[1]

	Thickness			
	Beds		Total	
	Feet	Inches	Feet	Inches
TONOLOWAY FORMATION				
Platy limestone and interbedded calcareous shales. The limestone breaks, on weathering, into thin hard ringing plates.				
WILLS CREEK FORMATION				
Argillaceous limestone and calcareous shale containing a bed of sandstone beneath the top of unit. Both limestone and shale weather readily to soil. Part of this unit is concealed. *Leperditia alta* occurs at 110 feet and at 7 feet above base of unit. Thickness approximate	200	0	449	3
Thin-bedded limestone used in manufacture of cement.	11	0	249	3
Thin-bedded limestone containing *Leperditia elongata willsensis*	5	0	235	3
Concealed. Thickness estimated	87	0	233	3
Thin-bedded limestone with some shale. Shaly and somewhat weathered at top	40	0	146	3
Gray cement rock	18	0	106	3
Dark-gray to black limestone with some dark-colored shale	12	0	88	3
Thin-bedded limestone. Three feet below top occur *Actinopteria* sp., *Leperditia alta*	9	0	76	3
Compact limestone	2	0	67	3
Calcareous shale. *Leperditia alta* occurs 2 feet below the top. *Leperditia alta, L. alta brevicula, Klœdenia normalis, Euklœdenella punctillosa, Klœdenella immersa* occur 6 feet below top	6.6	0	65	3
Compact limestone containing at top *Leperditia alta, L. alta brevicula Klœdenia normalis, Euklœdenella punctillosa, Klœdenella*	20	0	58	11
Calcareous sbale	4	6	56	11
Concealed. Probably shale	9	0	52	5
Arenaceous shales	7	0	43	5

[1] Upper beds measured by L. W. Stephenson; lower beds by C. K. Swartz.

Bloomsburg Member	Thickness: Beds Feet	Beds Inches	Total Feet	Total Inches
Greenish-gray and reddish-brown shale. A bed of sandstone 1 foot thick at top and some sandstone layers near bottom	12	0	36	5
Massive red sandstone	2	2	24	5
Arenaceous shale, mottled red	1	0	22	8
Cedar Cliff limestone consisting of:				
Interbedded limestone and shale, gray	3	0	21	3
Compact gray limestone. *Leperditia alta* occurs 1 to 2 feet below top of unit	5	0	18	3
Arenaceous shale	1	3	13	3
Green and red shaly sandstone	1	0	12	0
Greenish arenaceous shale containing calcareous nodules in vertical lines in lower part	3	0	11	0
Red arenaceous shale containing some limestone nodules	2	0	8	0
Red sandstone	0	6	6	0
Red shale	2	0	5	6
Compact sandstone. Upper 8 inches red, lower beds greenish	3	6	3	6
Total thickness of Wills Creek formation approximately			449	3
McKENZIE FORMATION				
Thin-bedded, argillaceous sandstone, greenish above, dark below, with numerous worm borings parallel to bedding	6	0	..	..
Drab shale fissile above, worm borings below	4	0	..	..
Fissile drab shale with thin bands of limestone.				

VII. Section at Mullen's Quarry, Cumberland

Mullen's quarry is situated on the Valley Road, west of the southern extremity of Shriver Ridge, in Cumberland. The quarry is opened in the middle beds of the Tonoloway formation which are purer and better adapted for burning into lime than the upper and lower parts of the formation.

The section described begins at the base of the exposure in the quarry and extends up the slope of Shriver Ridge, terminating at the base of the Helderberg formation. The upper beds are largely concealed. This locality is of interest because of the occurrence in the quarry of numerous cephalopods including species of Tetrameroceras, Trochoceras, etc.[1]

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
HELDERBERG FORMATION			
Nodular limestone above, concealed below.			
TONOLOWAY FORMATION			
Largely concealed. Occasional outcrops of gray, platy limestone. Road crosses the line of traverse and doubling back upon itself crosses the traverse a second time at top	317	200	615.3
Dark-gray, thick-bedded limestone	101	2.5	415.5
Concealed	98	82	413
Top of quarry	..	..	331
Concealed	..	3	331
Calcareous shale. Thickness estimated	..	3	328
Light-gray to dark-gray limestone, massive below, containing near top *Stenochisma lamellata, Rhynchospira globosa, Schuchertella rugosa, Tentaculites gyracanthus*, bryozoa. The *Stenochisma lamellata* zone. A bed of travertine at 78 feet horizontally, above which the rocks are much weathered. N. 27° E. 37° E	..	19	325
Massive, dark-blue to black limestone becoming thin-bedded upon weathering. A few light-gray bands appear at the top of unit	..	24	306
Clay seam	..	..	..
Dark-colored limestone. Thin-bedded below; thick-bedded above. N. 27° E. 37° E. At top of this unit occur *Hormatoma rowei, Trocheras ? marylandicum, Tetrameroceras cumberlandicum*. At the bottom of unit occurs *Hormatoma rowei* var. *nana*	..	32	282
Concealed to base of formation about	..	250	250
Thickness of Tonoloway formation approximately...			615.5

VIII. Section at Hyndman, Pennsylvania

Hyndman is situated a few miles north of the Maryland-Pennsylvania line on the western flank of Wills Mountain anticline. The Helderberg formation is well exposed in several quarries in this vicinity and the

[1] Measured with tape by C. W. Cooke, O. B. Hopkins, and W. A. Price, Jr., under the supervision of C. K. Swartz. The slope of the hill is 20 degrees.

sections seen in them have been described in the report on the Lower Devonian of Maryland.[1]

The section described is seen in and near one of these quarries [2] which is situated about one-third mile southwest of the Baltimore and Ohio Railroad station on the northern side of a hill.

The traverse begins at the Helderberg-Tonoloway contact and extends thence eastward 584 feet horizontally along the slope of the hill.[3]

	Horizontal distance from beginning of traverse to bottom of beds Feet	Thickness Beds Feet	Thickness Total Feet
HELDERBERG FORMATION			
The following section is seen in the quarry:			
Thin-bedded, dark-blue limestone with some heavy nodular beds weathering to a gray-blue color, containing a great abundance of fossils. At top *Batostomella interporosa* (a), *Atrypa reticularis* (aa), *Orthoceras* sp., *Aulopora* (?) *schucherti*, *A. schohariæ*, *Camarotœchia litchfieldensis* (c), *Stenochisma* (?) *deckerensis* (c), *S. formosa* (c), *Uncinulus* (?) *convexorus* (c). At the bottom occur *Camarotœchia litchfieldensis* (c), *Stropheodonta varistriata* (r)	..	18.5	48.3
Dark-blue limestone, thin-bedded toward top, heavy-bedded at bottom	..	19.9	29.8
Heavy-bedded, dark-blue limestone, containing at the bottom *Leperditia* sp., *Stenochisma* sp.	..	9.9	9.9
TONOLOWAY FORMATION			
Argillaceous, thin to heavy-bedded platy limestone	..	15	609
Eastern end of quarry [4]	..	..	..
The section is continued along the hillside east of the quarry. Traverse N. 87° E.			
Concealed	185	133	594
Thin-bedded, blue-gray limestone	195	7	461
Shale and shaly limestone, partially concealed	245	36	454
Thin-bedded, blue limestone	255	7	418
Concealed	270	11	416

[1] Md. Geol. Survey, Devonian, 1913, pp. 153-155.

[2] The section in this quarry is called Section B and is described on pp. 154, 155 in the volume referred to.

[3] Measured by C. W. Cooke, O. B. Hopkins, W. A. Price, Jr., and revised by C. K. Swartz.

[4] The average strike and dip used in calculating the remainder of the section is N. 26° E. 55° W.

	Horizontal distance from beginning of traverse to bottom of beds Feet	Thickness Beds Feet	Thickness Total Feet
Very fossiliferous, gray-blue limestone containing at base *Camarotœchia litchfieldensis* (a), *C. tonolowayensis* (a)	280	7	400
Blue-gray limestone, thin-bedded	290	7	393
Calcareous shale and shaly limestone, partially concealed	308	13	386
Thin-bedded, light-blue limestone very fossiliferous, containing *Camarotœchia litchfieldensis* (a) (366 feet stratigraphically)	318	7	373
Limestone, thin to medium-bedded above, more shaly below. Partially concealed. The base of this unit is 30 feet above the point at which the traverse begins. *Tetrameroceras cumberlandicum* was found at 415 feet horizontally (296 feet stratigraphically. *Modiolopsis gregarius* occurs at 440 feet horizontally (281 feet stratigraphically)	584	191	366
Concealed to base of Tonoloway about	..	175	175
Approximate thickness of the Tonoloway formation			609

B. Sections in Tussey Mountain Anticline

IX. Section on National Road, Martin Mountain

The best section of the Tonoloway formation in the Flintstone area is exposed along the National Road on Martin Mountain, 3 miles west of Flintstone.[1]

The section is, unfortunately, complicated by folds and is partially concealed, rendering its interpretation difficult. The correlation of the beds observed in the different folds here given is as perfect as could be made after considerable study, but is not entirely assured. In order to assist the student the relations to the beds in the various folds is indicated in the description of the section.

The horizontal traverse begins at the Helderberg-Tonoloway contact at the east end of a small quarry on the north side of the National Road, 1300 feet east of the forks of the road at the top of the mountain and 226 feet west of a concrete culvert situated at the right-angled turn in the road. The altitude of this point is about 1550 feet above tide upon the U. S. topographic map of this area.

[1] Md. Geol. Survey, Devonian, 1913, p. 157. This is a continuation of the section of the Keyser member of the Helderberg formation described.

The traverse descends the mountain toward the east and terminates at the cross road just west of the stone dwelling at the foot of the mountain. The altitude of the latter point is 1185 feet above tide.

The section extends from the base of the Helderberg formation to the top of the Wills Creek, though the lower beds are largely concealed.[1]

HELDERBERG FORMATION

Massive, fossiliferous nodular limestone N. 30° E. 64° E. containing fossils of the Keyser limestone.

TONOLOWAY FORMATION Traverse S. 81° E.	Horizontal distance from beginning of traverse to top of bed Feet	Thickness Beds Feet	Thickness Total Feet
Tonoloway-Helderberg contact. Altitude about 1517 feet; map altitude about 1550 feet.			
Rotten, shaly, argillaceous limestone. At the top of this unit occurs *Spirifer corallinensis.* 1.5 feet below the top *Camarotœchia litchfieldensis* var. *marylandica, Spirifer corallinensis*	53.5	45.3	609.0
Concealed. Occasional exposures of calcareous shale.	147.5	78.0	564.0
Shaly limestone. Dip 57° W. Partially concealed	158.5	8.9	486.0
Concealed	205.0	38.2	477.0
Laminated limestone; upper strata thin-bedded, lower 3 feet heavier-bedded. N. 28° E. 63° W. Seven feet below the top of unit at 216 feet horizontally occurs *Modiolopsis gregarius*	220.0	12.0	439.0
Concealed	226.0	3.0	427.2
West end of north culvert at right-angled turn of the road. Axis of minor anticline	226.0	..	..
Traverse S. 26° E.			
Concealed in large part. Minor folding. At 415 feet horizontally occurs *Leperditia alta*	676.0	..	..

[1] Measured by C. K. Swartz assisted by R. Leibensperger and G. Taylor. Altitudes are from the survey of the State Roads Commission of Maryland. In calculating thicknesses of the beds the following strike directions were employed:

Horizontal traverse	Strike of beds
1256 to 1653	N. 26° E.
1653 to 1951	N. 18° E.
1951 to 2757	N. 26° E.
2757 to 3700	N. 20° E.

Traverse S. 13° E.	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed	1226.0	..	..
Thin-bedded, shaly limestone	1256.0	4.0	424.7

Traverse S. 29° E. Altitude of turn 1501 feet, map altitude 1420 feet

Platy argillaceous limestone, weathering into beds 1 to 4 inches thick	..	1.1	420.2
Calcareous shale	..	0.4	419.1
Hard, dark-blue limestone weathering into thin beds with undulating surfaces	..	2.0	418.7
Massive, dark-gray limestone, breaking irregularly	1316.0	1.0	416.7
Concealed save for a few beds of thin-bedded, platy limestone. Dip 10° W. At 1416 feet horizontally shaly limestone. Dip 23° W. The east end of a concrete culvert is at 1424 feet horizontally. 9.7 feet below the top of unit at 1346 feet horizontally occurs *Camarotœchia litchfieldensis*	1435.0	34.1	415.7
Massive gray limestone. Some layers stained pink. Dip 69° W	1437.0	1.5	381.6
Travertine (brecciated limestone)	1438.0	0.8	380.1
Limestone, stained pink, weathering yellow and breaking into irregular fragments. Partially concealed	1440.7	3.0	379.3
Fissile, thin-bedded, shaly limestone with some impure heavier-bedded bands of limestone 6 feet below top	1470.0	22.9	376.3
Massive, dark-blue, fossiliferous limestone containing numerous crystalline bands. N. 26° E. 61° W. At top of unit occur *Hindella congregata, Leperditia alta.* About 3.4 feet below top (1476 feet horizontally) occur *Camarotœchia litchfieldensis* and *Hindella congregata*	1481.0	6.2	353.4

Traverse S. 69° E. Altitude of turn 1494 feet. Map altitude 1400 feet

Beds same as preceding unit. N. 26° E. 61° W. Telegraph pole at 1496 feet horizontally. At the bottom of unit occur *Hindella congregata, Leperditia alta, Welleria obliqua, Dizygopleura subovalis, D. halli*	1482.5	2.3	347.2
Blue, laminated, argillaceous limestone, breaking into thin laminæ containing a few thicker beds. The upper 2 feet are quite argillaceous and weather to a yellowish tone. Dip 55° W	1493.0	11.5	344.9
Calcareous shale. N. 31° E. 53° W	1495.0	1.7	333.4
Travertine	1496.0	0.8	331.8

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Total Feet
Hard, blue laminated limestone with beds 6 feet thick at top, another bed of hard, medium-bedded limestone in the middle 3 feet thick. The remainder is argillaceous limestone weathering yellowish. N. 31° E. 53° W	1512.0	12.0	330.9
Fissile, laminated, blue limestone, weathering light blue. N. 22° E. 57°	1525.0	14.9	318.9
Impure, argillaceous limestone containing some laminated blue limestone. Partially concealed. N. 29° E. 55° W	1541.0	10.3	304.0
Thin-bedded, hard, blue, crystalline limestone, very fossiliferous. About 4 feet below the top of unit (1545 feet horizontally) occurs *Hindella congregata, Leperditia alta, Welleria obliqua, Dizygopleura subovalis, D. halli*	1550.0	9.0	293.7
Argillaceous limestone and calcareous shale. A few beds of blue limestone	1565.0	13.8	284.7
Nodular limestone, very fossiliferous. Near top occurs *Schuchertella rugosa, Camarotœchia litchfieldensis, Leperditia alta, Welleria obliqua, Dizygopleura subovalis, D. halli.* Three feet from the top there is a band, 3 inches thick, made almost entirely of shells	1578.0	9.6	270.9
Thin-bedded, blue limestone weathering light-colored.	..	3.3	261.4
Massive blue limestone, weathering to a very light tone. Calcite seams are profuse	1578.0	4.0	258.2
Medium to thin-bedded, blue limestone. Calcite seams profuse. The lower part shows light and dark bands	1587.5	9.6	254.3
Medium-bedded, blue limestone weathering gray	..	7.0	244.7
Heavier-bedded gray limestone, lower part blue	1614.0	1.3	237.7
Mostly concealed. Medium-bedded, bluish-gray limestone	1631.0	13.5	236.4
Laminated, dark-blue limestone	1653.0	5.5	222.9
Axis of anticline	1653.0	..	217.4

The section is duplicated between 1653 feet horizontally and 3356 feet horizontally by repetition by folding and should be omitted from estimates of the total thickness. The beds are described to aid in the interpretation of the section.

Road N. 70° E. Altitude of turn 1479 feet, map altitude 1380 feet

Thin-bedded laminated limestone, repeating beds 1637 to 1653 feet horizontally	1664.0	5.5	..
Concealed. Shaly limestone in part. N. 20° E. 47° E.	1673.0	..	..

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Medium-bedded limestone with some thinner beds. N. 18° E. 58° E.	1703.0	..	..
Thin-bedded, blue limestone. 1712 feet horizontally repeats 1587.5 feet horizontally. N. 18° E. 58° E.	1712.0	..	..
Massive, dark-blue limestone with some interbedded shale and one band of rotten yellow limestone. The upper beds are nodular. N. 14° E. 45° E. Nine inches below the top of this unit (1737 feet horizontally, approximately 271 feet above the base of the formation) occur bryozoa, *Schuchertella rugosa*, *Camarotœchia litchfieldensis*. 1737 feet horizontally repeats 1566 feet horizontally	1738.0	..	..
Calcareous shale, concealed in part. N. 20° E. 47° E. 1755 feet horizontally repeats 1550 feet horizontally.	1755.0	..	..
Blue limestone, the lower 3 feet containing some thick beds. The remainder is thin-bedded and breaks irregularly. Dip 55° E. At the top of this unit approximately 296 feet above the base of the formation (1772 feet horizontally) occur *Hindella congregata*, *Welleria obliqua*, *Dizygopleura subovalis*, *D. halli*. Four feet below the top of this unit (1766 feet horizontally, approximately 290 feet above base of the formation) occur *Camarotœchia litchfieldensis*, *Hindella congregata*. 1773.5 feet horizontally repeats 1541 feet horizontally	1773.5	..	..
Thin-bedded argillaceous limestone. Dip 56° E.	..	2.4	..
Thick-bedded, very impure, argillaceous limestone. N. 14° E. 52° E. 1785 feet horizontally repeats 1525 feet horizontally	1785.0	1.3	..
Thin-bedded, blue limestone. N. 17° E. 65° E. 1803 feet horizontally repeats 1512 feet horizontally	1803.0	..	..
Concealed. In part argillaceous limestone	1810.0	..	..
Blue, laminated limestone, medium to thin-bedded, concealed in part. N. 14° E. 60° E. A very impure argillaceous limestone 1821.5 to 1825.5 feet horizontally. The latter may represent the travertine bed at 1.496 feet horizontally	1830.0	..	..
Hard, blue limestone, massive crystalline limestone at top; thin-bedded limestone 3 feet below top. A massive ledge 3.5 feet thick at the base. Beds at 1836 and 1841 feet horizontally are somewhat nodular N. 22° E. 60° E. 1830 feet horizontally repeats 1470 feet horizontally. Four feet below the top of			

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
this unit (1844 feet horizontally, approximately 351 feet above the base) occur *Camarotœchia litchfieldensis, Hindella congregata* var. *pusilla, Leperditia alta, Tentaculites gyracanthus* var. *marylandicus.* About 7 feet below the top of this unit (1840 feet horizontally, approximately 346 feet above the base of the formation) occur *Camarotœchia litchfieldensis, Hindella congregata, Tentaculites gyracanthus* var. *marylandicus, Leperditia alta*	1850.0	..	..
Calcareous shale. Largely concealed. 1868 feet horizontally repeats 1481 feet horizontally	1868.0	..	..
Blue limestone. Heavy-bedded at base, thinner bed above. Dip 70° E. This may represent the beds in the unit between 1440 and 1470 feet horizontally	1876.0	..	..
Largely concealed. Some shaly limestone W. 22° E. 48° E.	1896.0	..	..
Massive, blue limestone weathering to a light color. Probably repeats unit between 1435 and 1437 feet horizontally	1898.0	1.5	..
Largely concealed. Some calcareous shale at base. Telephone pole 2067 at 1930 feet horizontally	1951.0	..	..
Axis of syncline	1951.0	..	..
Eastern limb of syncline. The beds between 1951 and 3356 feet horizontally repeat those between 1653 and 1951 feet horizontally	..	..	..
Concealed. At the bottom of this interval is a massive limestone 2 feet thick, which may be the ledge seen at 1435 to 1437 and at 1896 to 1898 feet horizontally. N. 22° E. 25° E.	1980.0	..	..
Largely concealed. Some calcareous shale in lower part. N. 22° E. 70° W. At 2079 feet horizontally occurs a ledge of limestone similar to that at 1980 feet horizontally. 2103.5 feet east end of a concrete culvert	2110.0	..	..
Blue, highly fossiliferous, crystalline limestone. The upper 2 feet and lower 1 foot are heavily-bedded, the middle 3 feet weathering into beds 1 inch thick. Dip 25° W. At top, approximately 351 feet above the base of the formation, occur *Hindella congregata, Leperditia alta.* At 2115 feet horizontally, approximately 346 feet above the base of the formation, were found *Stropheodonta varistriata, Camarotœchia*			

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
litchfieldensis, *Tentaculites gyracanthus*, *Hindella congregata*, *Holopea flintstonensis*, *Hormatoma rowei*, *Solenospira minuta*, *Orthoceras* sp., *Welleria obliqua*, *Dizygopleura subovalis*, *D. halli*. 2110 feet horizontally repeats 1850 and 1470 feet horizontally. 2115 feet horizontally repeats 1842 feet horizontally and lies near the horizon of 1482 feet horizontally..	2118.0	6.0	..
Thin-bedded, laminated limestone	2126.0	5.0	..
Largely concealed	2151.0	..	..
Medium to thin-bedded limestone. Dip 24° W........	2160.0	..	..
Concealed. Travertine boulder occurs at the bottom of unit, which may repeat the travertine at 1496 feet horizontally. At 2190 feet horizontally, 325 feet stratigraphically, occurs *Hindella congregata*......	2174.0	..	..
Concealed. At 2206 and 2222 feet horizontally are boulders of brecciated limestone. At 2190 feet horizontally occurs *Hindella congregata*..............	2272.0	..	..

Road N. 55° E. Altitude of turn 1434 feet, map altitude 1360 feet

Concealed	2298.0	..	..
Thin-bedded, laminated limestone. Dip 21° W. and 15° W.	2305.0	3.0	..
Concealed. 2372.5 feet horizontally is telephone pole 2164. At 2450 feet horizontally is a bed of laminated thin to medium-bedded limestone. Dip 28° W. and 24° W. About 2314 feet horizontally, approximately 308 feet above the base of the formation, occur *Leperditia alta*. At 2396 feet horizontally, approximately 296 feet abovethe base of the formation, occur *Halliella fissurella*, *Leperditia alta*, *Aparchites punctillosa*, *Welleria obliqua*, *Dizygopleura subovalis*, *D. halli*. At 2450 feet horizontally occur *Hindella congregata*, *Solenospira minuta* ?, *Leperditia alta*. About 2478 feet horizontally, approximately 291 feet above the base of the formation, occur *Camarotœchia litchfieldensis*, *Hindella congregata*, *Leperditia alta*, *Welleria obliqua*, *Dizygopleura subovalis*, *D. halli*. At 2514 feet horizontally, approximately 281 feet above the base of the formation, occurs *Camarotœchia litchfieldensis*. 2478 feet horizontally, probably approximates the horizon at 1546 feet horizontally	2514.0	..	..

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Nodular limestone, containing numerous sand grains. Dip 4° W. In this unit, about 271 feet stratigraphically, occur bryozoa, *Rhynchospira globosa*, *Hindella congregata*, *Proetus* ? sp., *Dizygopleura subovalis*, *D. halli*	2546.0	..	..
Concealed in part. On the north side of the road, between 2456 and 2626, are 2.5 feet massive, nodular limestone, dip 10° W., containing approximately 271 feet above the base of the formation, *Schuchertella rugosa*, *Camarotœchia litchfieldensis*, *Hindella congregata*, *Leperditia alta*, *Welleria obliqua*, *Dizygopleura subovalis*, *D. halli*, underlain by massive, dark-blue, crystalline limestone 2 feet thick. The top of this ledge is 7 feet above the road. The nodular limestone of the above bed may be the same as that at 2546 and repeats the beds seen at 1736.5 and 1566 feet horizontally	2757.0	..	..
Thin to medium-bedded limestone seen in the gutter. Dip 7° E. At 2784 horizontally, approximately 256 feet above the base of the formation, occur *Rhynchospira globosa*, *Hindella congregata*, *Leperditia alta*. 2840 feet horizontally is situated telephone pole 2061. Thin-bedded, argillaceous limestone becoming rotten on exposure. Dipping with road. About 2871 feet horizontally, approximately 248 feet above the base of the formation, occur *Hindella congregata*, *Leperditia alta*	2871.0	..	..
Road N. 20° E. Altitude of turn 1392 feet, map altitude 1400 feet			
Thin-bedded, argillaceous limestone. At 2908 feet horizontally (about 246 feet stratigraphically) occurs *Hindella congregata*	2938.0	..	..
Concealed	3039.0	..	..
Thin-bedded, argillaceous limestone	3053.0	..	..
Hard, blue limestone, weathering into bed 2 to 6 inches in thickness. *Leperditia alta* occurs about 3085 feet horizontally, approximately 239 feet above the base of the formation	3091.0	..	..
Medium to thin-bedded blue limestone. *Leperditia alta* occurs about 3100 feet horizontally, approximately 236 feet above the base of the formation	3121.0	..	..

Road N. 5° W. Altitude of turn 1372 feet, map altitude 1380 feet

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Medium to thin-bedded blue limestone. A heavy bed outcrops at 3166 feet horizontally. At 3267 horizontally is located the west end of a concrete culvert.	3271.0	..	..
Laminated limestone and calcareous shale. This unit may possibly represent the laminated limestone in the center of the anticline at 1631 to 1653 feet horizontally. The top of this unit is 5 feet above the road bed	3276.0	..	..
Concealed. 3356 feet horizontally is approximately the horizon of the center of the anticline at 1653 feet horizontally.			
The section is resumed at base of latter unit.			
Thick, medium-bedded, dark-blue limestone with some interbedded calcareous shale. At 3434 is located telephone pole 2057. This unit contains *Hindella congregata* abundant, *H. congregata* var. *pusilla*, *Hormatoma rowei* var. *nana*, *H. rowei*, *Aparchites punctillosa*, *Welleria obliqua*, *Dizygopleura subovalis*, *D. halli*. 7.4 feet above base of unit (3535 feet horizontally) occur *Spirifer vanuxemi* and *Camarotœchia tonolowayensis*	3750.00	13.0	218.4

Road N. 53°. Altitude of turn 1323 feet, map altitude 1360 feet

The following section is exposed in a small quarry on the north side of the road:			
Argillaceous limestone. Some courses are 8 inches thick. Upper layers brecciated and highly fossiliferous. Some interbedded calcareous shale. *Hindella congregata*, *Hormatoma rowei* var. *nana*, *Modiolopsis leightoni* occur near the top	..	4.3	205.5
Calcareous shale. *Hindella congregata*, *Orthonota* ? *marylandica*, *Solenospira minuta* occur at top of unit	3782.0	1.4	200.9
Massive, dark-blue limestone in one course, forming a ledge above the concrete culvert at the sharp turn of the road. *Eurypteris flintstonensis* occurs 9 inches below the top of this unit	3786.0	1 5	199.5
Shaly limestone	..	0.4	198.0
Dark-blue limestone. Thick-bedded above, laminated below like the underlying unit from which it is separated by a parting plane	..	6.3	197.6

10

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Dark-blue, argillaceous limestone. Upper half of unit laminated, consisting of thin, light, and dark films; lower half thicker-bedded. At 3800 is situated the east end of an acute-angled concrete culvert. At 3888 feet horizontally the axis of a minor syncline	3934.0	9.3	191.3
The section is resumed east of the quarry.			
Thin-bedded blue limestone. The upper part of this unit is like the one which forms the base of the quarry section. Dip 16° W. *Hindella congregata* occurs 1.5 feet below the top (3940 feet horizontally)	3952.0	4.5	182.0
Traverse S. 85° E. Altitude of turn 1309 feet, map altitude 1300 feet.			
Similar to overlying unit, but lower part thinner-bedded. A heavy bed occurs 2.5 feet below the top. Dip 13° W.	4016.0	19.0	177.5
Thin-bedded, shaly laminated limestone, weathering into tbin sheets, lower beds more argillaceous. A few heavier beds. Dip 11° W. Telephone pole 2053 at 4026 feet	4125.0	27.0	158.5
Very impure argillaceous limestone, weathering yellow. A few thicker beds. Dip 11° W. *Leperditia alta* occurs 7.5 feet above base of unit (about 4196 feet horizontally)	4226.0	24.5	131.5
Argillaceous limestone. Dip 11° W.	4241.0	3.5	107.0
Calcareous shale, weathering yellow. Dip 11° W.	4283.0	10.5	103.5
Argillaceous limestone. Dip 12° W. *Leperditia alta* occurs 1 foot above base of unit (4291 feet horizontally)	4296.0	3.0	93.0
The section is concealed east of this point, save for occasional outcrops of blue limestone, between 4705 and 5370 feet horizontally, *Leperditia alta* occurs 11 feet below top (4340 feet horizontally). The thickness of this unit is estimated to be 90 feet approximately	..	90.0	90.0
Approximate thickness of Tonoloway formation.			609.0

WILLS CREEK FORMATION

Concealed	5364.0	..	..
Center of cross road leading north and south	5364.0	..	..
A sandstone, probably the upper sandstone of the Wills Creek formation, outcrops on a small knob east of this road opposite the stone dwelling house	..	..	..

X. Section at Flintstone

An excellent section of the Wills Creek formation is seen on the east bank of Flintstone Creek, north of the village of Flintstone. The section begins at the base of the red beds of the Bloomsburg member which form a projecting cliff on the east bank of the stream, 1850 feet north of the National Road and terminates at the stone bridge where the National Road crosses the creek.

The horizontal traverse begins at the top of the massive red sandstone which forms the uppermost bed of the Bloomsburg member seen in the cliff. An almost uninterrupted exposure of these strata is seen in the cliffs east of the creek, save in the lower part of the section. The same beds outcrop in the roadway above the cliff where certain of the fossils listed were collected. This locality affords the finest exposure of the Wills Creek formation in the Flintstone area. The section[1] is a continuation of the section of the McKenzie formation described on page 81.

TONOLOWAY FORMATION

Traverse S. 30° E.

	Horizontal distance from beginning of traverse to top of bed	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Southwest corner of stone wall around the yard of a brick house situated on the north side of the National Road and east of bridge	1838.0	..	..	..	..
Concealed	1838.0	..	..	..	..
Thin to medium-bedded limestone N. 35° E. 45° E.	1802.0	10	7	49	4
Concealed	..	25	4	38	9
Limestone. Lower part heavy-bedded, drab-gray; upper part thinner-bedded, light-gray. The strike of the bottom of this bed is in line with the west end of the stone bridge	1742.0	13	3	13	5
Thickness of Tonoloway formation described				49	4

[1] Measured by R. Leibensperger and G. Taylor under supervision of C. K. Swartz. Beds and traverse were measured by tape.

WILLS CREEK FORMATION

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Concealed	1734.0	10	6	511	1
Traverse S. 10° W.					
Dark-blue, argillaceous limestone, thin to medium-bedded. Dip 47° E.	1717.0	11	4	500	7
Fissile, dark-gray, calcareous shale. Dip 55° E.	1697.0	9	8	489	3
Dark-blue, argillaceous limestone in beds about 2 inches thick, interbedded with calcareous shale. Nine feet above the base of unit is a bed of curly limestone which suggests a Stromatoporoid	1679.5	17	6	479	7
Very fissile, dark-gray, calcareous shale, some interbedded bands of dark-blue limestone at bottom. The shale smooth, almost unctuous	1647.0	4	10	462	1
Single course of dark-blue argillaceous limestone, intersected by calcite seams	1638.7	0	8	457	3
Laminated, hard, blue limestone	1637.5	4	4	456	7
Compact, somewhat arenaceous blue limestone, weathering brown	1630.0	2	6	452	3
Thin-bedded, fissile, calcareous shale. Upper part contains thick layers of hard brown mud rock. The base of this unit is in line with west end of a white house	..	3	6	449	9
Traverse S. 22° W.					
Single course of gray sandstone	1619.0	1	4	446	8
Greenish-gray, argillaceous limestone, breaking irregularly	..	9	0	444	11
Single course of limestone 1 foot thick, upper part dark-gray, lower part greenish-gray	1583.0	4	4	435	11
Very impure argillaceous limestone breaking irregularly	..	5	7	431	7
A 2-inch band of limestone at top and bottom of unit. Intervening part is a dark-gray, fissile shale. (This unit is best seen above cliff, formed by unit described at 1521 feet horizontally)	..	1	10	426	0
Single course dark-blue argillaceous limestone	..	1	0	424	2
Very thin-bedded, dull shale	..	1	10	423	2

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Massive, compact, bluish-gray limestone which weathers brown and breaks irregularly. A shale band 5 inches thick occurs 11 inches below top	1521.0	7	6	421	4
Massive, greenish-gray limestone intersected by calcite seams parallel to bedding plane. Dip 30° E. The upper 6 inches is a thin-bedded, brown arenaceous shale. This unit and the next form most of the cliffs seen from the National Road	1468.0	7	6	413	10
Thin-bedded, fissile, arenaceous shale which weathers to a greenish tone, interbedded with thicker arenaceous bands, becoming more compact near the top and blending into overlying unit. Dip 45° E.	..	4	0	406	4
Heavy, medium and thin-bedded, dark-blue argillaceous limestone and some interbedded shale, part of which is arenaceous. Courses 1 foot thick form top and bottom with intervening beds of varying thickness. One foot 6 inches above the base occurs *Leperditia alta*	..	9	8	402	4
Massive, green, somewhat arenaceous limestone with a few thinner beds of limestone and some inter-bedded shale. The top of this unit is best seen at 1085 feet horizontally. Dip 45° E. (Average of three observations.) At base a thin bed of blue, crystalline, fossiliferous limestone containing *Schuchertella interstriata* common, *Camarotœchia litchfieldensis* common, *C. tonolowayensis*, *Uncinulus obsolescens*, *Spirifer corallinensis*, cf. *Hindella congregata*. *Leperditia alta* occurs near top and near base of unit	1289.0	29	6	392	8
Traverse S. 9° E.					
Single ledge of blue, magnesian limestone, plunging into creek	1061.0	0	7	363	0
Greenish, somewhat arenaceous mud rock, weathering to a dirty gray. *Leperditia alta* occurs 2 feet above the base. Three feet above the base occur *Leperditia alta*, *L. brevicula*, *Klœdenia normalis*	..	3	8	362	7

Traverse S. 3° W.

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Heavy-bedded, dark-gray argillaceous limestone, weathering yellow	..	2	0	358	11
Very fissile shale, dark-gray to black. Some parts papery, upper part crinkly. Dip 40° E. In this unit occur *Gypidula* sp., *Camarotœchia litchfieldensis, Uncinulus obsolescens, Calymene camerata. Leperditia alta* occurs near base	..	2	6	356	11
Very impure argillaceous limestone, breaks irregularly. In the middle of this unit occurs *Leperditia alta*	..	1	10	354	5
Mottled sandstone	..	1	2	352	7
Thin-bedded, compact, banded, gray limestone with a few inches of shale near the top. The lower part of this unit is largely concealed	..	4	0	351	5
Yellow mud rock breaking into fine pieces; a porous band 3 inches above base. The upper 6 inches are very arenaceous	..	2	2	349	5
Heavy bed of gray argillaceous limestone, 8 inches thick forms base of unit. The middle consists of thick and thin brown layers, the upper part of thin-bedded, gray, banded argillaceous limestone	..	6	8	345	3
Calcareous mud rock, fracture irregular and hackly. Upper and lower parts gray; middle greenish. The upper beds are shaly, the lower arenaceous. W. 35° E. 25° E. *Leperditia alta* occurs about 5 feet above the base of unit	..	13	0	338	7
Medium to thin-bedded limestone (porcelain-like). W. 35° E. 30° E	..	3	4	325	7
Concealed	..	8	0	322	3
Hard, dark-blue limestone, laminated	..	5	0	314	3
Calcareous mud rock. The upper part is somewhat shaly and breaks irregularly. Dip 25° E.	..	6	0	309	3
Thin-bedded arenaceous shale. Some layers are very arenaceous, the upper 18 inches being sufficiently arenaceous to be called a sandstone, weathering slightly greenish. Dip 31° E.	..	7	2	303	3

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Green, calcareous mud rock, breaking into very small pieces. The upper bed is more compact. Middle of unit is mostly concealed. Dip 35° E.	..	12	3	296	1
Medium to thin-bedded, laminated, gray argillaceous limestone	..	1	6	283	10
Concealed	..	8	2	282	4
Irregular-bedded, dark-blue limestone	..	4	6	274	2
Traverse S. 2° W.					
Impure, mottled, argillaceous limestone, brownish in color, breaks very irregularly. At base occur *Camarotœchia litchfieldensis* abundant, *Spirifer vanuxemi* abundant, *Hormatoma rowei, Calymene camerata, Leperditia alta*	714.0	1	0	269	8
Calcareous mud rock, somewhat greenish with very irregular fracture. Upper part massive, silghtly greenish, and more calcareous. *Leperitia alta* occurs at base	..	15	0	268	8
Hard, dark-blue, argillaceous limestone	665.2	2	0	253	8
Massive-bedded mud rock, irregular fracture. Some parts weather green, others brown. Some bands are arenaceous. The top of the unit is green and breaks very irregularly. A few thinner, harder, more regular and more arenaceous beds are found about 4 feet above the base	..	7	10	251	8
Calcareous shale weathering green, irregular fracture. *Leperditia alta* occurs at base and 5 feet above base of unit	..	5	0	241	10
Laminated arenaceous limestone, brownish color, containing *Leperditia alta*	..	3	3	238	10
Brown shale, somewhat arenaceous, beds of varying thickness	..	6	0	235	7
Concealed (mud rock shown on road)	..	11	0	229	7
Dark-blue to black limestone. Thin-bedded at top, heavy-bedded at bottom containing *Leperditia alta*	..	4	0	218	7
Massive, dark-gray mud rock, fracture irregularly, filled with black specks. *Leperditia alta* occurs at top and bottom of this unit	..	1	4	214	7

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Gray laminated limestone containing *Leperditia alta.* N. 35° E. 45° E.	..	3	8	213	3
Hard blue limestone. Upper 11 inches form a single bed. Lower part is thinner-bedded and grades into the underlying unit	550.7	4	0	209	7
Compact, laminated, argillaceous limestone and calcareous shale, dark-gray to black in color. The top of this unit becomes thinner-bedded and grades into the overlying beds. About 9 feet below the top of this unit occurs *Hindella congragata, Leperditia alta* abundant, *L. alta brevicula, L. altoides marylandica, Klœdinia normalis, K. normalis appressa, Zygobeyrichia ventricornis*	..	17	0	205	7
Blue limestone, heavy-bedded at base, becoming progressively thinner and more shaly towards top. Dip 40° E.	520.0	2	0	188	7
Thin-bedded, calcareous shale, becoming papery at top. This unit contains thin lenses of limestone	..	4	2	186	7
Dark-gray to blue limestone, weathering brown. Upper and lower layers thick-bedded, intervening layers thin-bedded. Dip 45° E.	..	4	0	182	5
Massive, somewhat arenaceous limestone, weathering greenish, breaking into irregular pieces. Full of black specks suggesting ostracod fragments. W. 35° E. 44° E. (Dip average of 4 observations)	..	4	6	178	5
Traverse S. 5° W.					
Thin-bedded, laminated, blue limestone, some beds compact. N. 35° E. 48° E. A band of limestone 3 inches thick occurs 13.6 feet above the base of this unit (405 feet horizontally). About 12½ feet above the base occur *Leperditia alta, Dizygopleura halli, K. immersa, Klœdenia wallpackensis*	422.0	24	6	173	11
Massive, dark-blue limestone with some thin beds. Two and a half feet below the top of the unit is a band of crinkled calcareous shale with some lenses of limestone. N. 35° E. 47° E. At base occur *Leperditia alta, Klœdenia normalis*	..	10	8	149	8

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Beds Inches	Total Feet	Total Inches
Concealed. N. 35° E. 41° E. (Dip the average of 2 observations.)	..	54	10	138	9
Massive, dark-gray to black, argillaceous limestone. This unit is exposed above the spring. N. 35° E. 49° E. (Dip the average of 2 observations.)	..	2	2	83	11
Concealed in large part. Some argillaceous limestone. N. 35° E. 54° E. (average of 3 observations)	..	52	9	81	9
Bloomsburg Member					
Massive, red sandstone	..	3	5	29	0
Calcareous shale, mottled pink and gray	..	1	5	25	7
Argillaceous blue limestone with interbedded calcareous shale weathering gray. *Leperditia alta* occurs near base. *The Cedar Cliff limestone*	..	8	9	24	2
Red shale. This unit contains calcareous nodules arranged in vertical lines. When weathered these nodules are gray and perforated with tubules	..	4	5	15	5
Red shale with a thin band of sandstone at top	..	1	0	11	0
Massive red sandstone	..	4	0	10	0
Red, arenaceous shale	..	6	0	6	0
Total thickness of Wills Creek formation				517	1
McKENZIE FORMATION					
Arenaceous shale, breaking irregularly and weathering green	..	6	0	..	..
Dark shale, almost black on fresh exposure, with some thin beds of limestone in lower part. This unit grades into the overlying unit and has no sharp line of division	..	13	0	..	..
Massive, dark-blue limestone, consisting chiefly of ostracods of the genera *Dizygopleura* and *Euklœdenella*	..	5	4	..	..
Klœdenia longula occurs in a thin band near the base of the Wills Creek above the Bloomsburg red sandstone	..	..	..	..	..

C. Sections in Cacapon Mountain Anticline

XI. Section at Round Top

One of the finest exposures of the Wills Creek formation in Maryland is exposed in the cuts of the Western Maryland Railway and on the banks of the Chesapeake and Ohio Canal at Rount Top, 3 miles west of Hancock.

The strata are much folded and somewhat faulted at this point, rendering the measurement of some of the beds difficult. By combining the measurements of various folds, however, an uninterrupted section of the Wills Creek formation can be obtained.

By uniting this section with that at Grasshopper Run, West Virginia, on the opposite side of the Potomac River, an almost continuous section may be obtained, extending from the base of the Wills Creek formation to the top of the Tonoloway. The composite section thus obtained is comparable to that seen at Pinto.

The Bloomsburg member of the Wills Creek formation is unusually well exposed at this place. It is folded into two very sharp anticlines which are traversed by the cuts of the Western Maryland Railway and are also finely seen on the banks of the Chesapeake and Ohio Canal.

The section described begins at the base of the Bloomsburg member of the Wills Creek formation and extends thence westward along the Western Maryland Railway to the lower beds of the Tonoloway formation. The horizontal traverse begins at the base of the red rock of the Bloomsburg member and extends westward, 3,304.5 feet. The upper beds of the McKenzie and the lower beds of the Bloomsburg are measured in the cut through the eastern anticline referred to above. The remainder of the section is measured in the western anticline and in the cuts west of it.[1]

[1] Section measured with tape by C. K. Swartz assisted by R. Leibensperger. Thicknesses of the beds were measured directly. The horizontal measurements were made along the northern rail of the track.

TONOLOWAY FORMATION

	Horizontal distance from beginning of traverse to top of bed	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Axis of minor syncline	3304.5	..	..	..	..
Finely laminated blue and yellow limestone. A bed of harder, more laminated, lenticular limestone occurs 4½ feet below top, containing *Leperditia alta*	3304.5	9	6	33	2
Compact blue limestone, intersected by calcite films	..	0	6	23	8
Dark-blue compact limestone conglomerate containing thin pebbles. *Leperditia alta* occurs at its base	..	0	3	23	2
Laminated calcareous shale, weathering yellowish. *Leperditia alta* occurs 2 feet above base	3260.5	4	6	22	11
Compact, deep-blue limestone. Streaked with numerous calcite films. Lower 4 inches like the underlying unit	3237.5	2	4	18	5
Limestone-sandstone and conglomerate, purplish-blue, top stained yellow	3224.5	2	4	16	1
Very impure laminated argillaceous limestone; a bed 1 foot thick in the middle is greenish. *Leperditia alta* occurs 6½ feet and 9 feet below top	3210.5	11	0	13	9
Rotten, yellowish limestone	3155.5	0	10	2	9
Thick-bedded, purplish-gray limestone. This unit may be described as a limestone sandstone or conglomerate, containing numerous sand grains and limestone pebbles	3150.5	1	11	1	11
Total thickness of Tonoloway formation exposed				33	2

WILLS CREEK FORMATION

	Horizontal distance from beginning of traverse to top of bed	Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Finely laminated, thick-bedded, impure argillaceous limestone. The upper part is stained yellow	3140.5	5	10	487	7
Thick-bedded, calcareous mud rock, non-laminated	3117.5	3	5	481	9
Finely laminated, calcareous shale, weathering to a greenish tone. Top of dark band 1 foot below top. *Leperditia alta* occurs throughout unit	3095.5	4	6	478	4

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Single course of blue, argillaceous limestone, not distinctly laminated	..	0	6	473	10
Laminated, argillaceous limestone, weathering light-colored	3067.5	5	3	473	4
Rotten, calcareous shale	3048.5	3	0	468	1
Section repeated by folding between 2920.5 feet and 3048.5 feet horizontally, hence not described.					
Axis of minor cyncline	2920.5	..	..	..	..
Calcareous shale and fissile, shaly argillaceous limestone. Upper 5 inches oölitic, beneath which is a thin bed of limestone conglomerate	2917.5	13	6	465	1
Thick-bedded, green shale, breaking irregularly and weathering green	2917.5	1	6	451	7
Thin-bedded limestone and interbedded shale	2910.5	1	6	450	1
Thin-bedded calcareous shale, weathering to a greenish tone. This unit contains occasional thin bands of limestone	2906.5	5	3	448	7
Argillaceous limestone with a bed of rotten shale 10 inches thick just above the middle	2887.5	3	3	443	4
Thin, fissile, calcareous shale. Calcite seams 3 feet 4 inches above the base. The upper 18 inches thicker-bedded, hackly, and breaking irregularly. *Leperditia alta* occurs 1 foot 5 inches above base	2865.5	6	6	440	1
West end of concrete retaining wall	2849.5	..	..	..	..
Argillaceous limestone	2826.5	0	7	433	7
Fissile, calcareous shale, with a few thin bands of limestone	..	4	3	433	0
Thin-bedded, argillaceous limestone with some interbedded shale	2796.5	4	4	428	9
Rotten, shaly limestone	2775.5	1	5	424	5
Single bed of argillaceous limestone	2767.5	1	3	423	0
Thin-bedded, dark-gray shale	..	0	8	421	9
Thick-bedded, calcareous mud rock, weathering greenish	2758.5	8	3	421	1
Very thin-bedded, calcareous shale with some thin bands of limestone	2694.5	3	8	412	10
Argillaceous limestone in 2 bands with an intervening bed of dark, gray, fissile calcareous shale	..	1	5	409	2
Dark, fissile, calcareous shale with occasional thin bands of limestone	2658.5	4	5	407	9

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Hard, thin-bedded, argillaceous limestone	2623.5	2	2	403	4
Fissile shale containing calcite seams	..	0	8	401	2
Massive, compact, blue sandstone, weathering brown with some thinner-bedded, somewhat shaly sandstone containing at 2604 feet horizontally (about 399 feet stratigraphically) bryozoa, *Camarotœchia litchfieldensis* abundant, and *Leperditia alta*	2613 5	5	6	400	10
Thin-bedded, arenaceous shale weathering green. Calcite seems parallel to bedding	2579.5	3	8	395	4
Very massive, deep-blue calcareous mud rock, weathering green	2566.5	4	6	391	8
Massive, interbedded, hard, brown sandstone and very argillaceous limestone which weathers green	2538 5	6	4	387	2
East end of concrete retaining wall	2467.5	..	..	..	..
Very thick-bedded, green calcareous mud rock, weathering green. Upper part a very impure, argillaceous limestone, lower foot red	2453.5	5	6	380	10
Red mud rock, single bed	2416.5	3	0	375	4
Thin-bedded, fissile calcareous shale and shaly limestone	2386.5	1	0	372	4
Rotten, brown, argillaceous limestone	..	1	0	371	4
Argillaceous limestone	..	0	3	370	4
Arenaceous green shale	2367.5	1	1	370	1
Thick-bedded, argillaceous limestone	2358.5	0	10	369	0
Thick-bedded, arenaceous green shale, breaking very irregularly	2354.5	1	8	368	2
Argillaceous limestone, upper 7 inches shaly, lower part thick-bedded	2337.5	3	5	366	6
Argillaceous, green sandstone	2319.5	3	8	363	1
Thin-bedded, arenaceous shale, breaking very irregularly	2301.5	4	0	359	5
Green, argillaceous sandstone	2287.5	0	10	355	5
Calcareous shale. Lower foot thin-bedded and fissile; remainder thicker-bedded, green and arenaceous	2282.5	2	9	354	7
Argillaceous limestone	..	0	6	351	10
Thin-bedded, rotten, brown limestone	..	0	10	351	4
Thin-bedded, argillaceous limestone with some shale. Calcite seams in lower part	2269.5	4	0	350	6

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Beds Inches	Total Feet	Total Inches
Very massive, impure limestone, breaking into very irregular fragments, deep-blue when fresh, yellowish-brown when weathered. This unit contains numerous irregularly shaped cavities probably formerly occupied by mud balls. Lower part arenaceous and grades into the underlying unit. *Leperditia alta* occurs at top	2250.5	19	0	346	6
Thick-bedded, calcareous, argillaceous sandstone weathering greenish. This unit passes by insensible gradations into the overlying bed	2183.5	2	0	327	6
Thin-bedded, banded, arenaceous shale weathering green	2172.5	2	0	325	6
Limestone sandstone with some quartz sand grains. *Leperditia alta* occurs throughout. *Camarotœchia litchfieldensis*, *Uncinulus marylandicus*, *Hormatoma rowei* occur at base	2167.5	1	2	323	6
Thick-bedded, argillaceous sandstone, weathering green	2161.5	2	0	322	4
Interbedded, thin-bedded argillaceous limestone and calcareous shale. The lower 14 inches a dense argillaceous limestone	2154.5	3	10	320	4
Thin-bedded, dark-gray calcareous shale	2143.5	0	9	316	6
Calcareous shale, weathering to greenish tone. Upper 12 inches heavier, argillaceous limestone carrying *Leperditia alta*	2139.5	4	6	315	9
Thick-bedded, banded argillaceous limestone weathering buff	2127.5	3	8	311	3
Thick-bedded mud rock breaking irregularly and weathering green	2110.5	2	7	307	7
Argillaceous limestone	2099.5	1	0	305	0
Interbedded, thin-bedded, argillaceous limestone and fissile shale	2092.5	8	4	304	0
Gray argillaceous shale	..	0	1	295	8
Thin-bedded, calcareous shale	2055.5	2	5	295	2
Argillaceous limestone	2038.5	1	8	292	9
West end of stone and concrete retaining wall which begins at 1569 feet horizontally	2031.5	..	..	..	..
Green arenaceous mud rock breaking very irregularly. The base of this unit is at 1920.5 feet horizontally	2020.5	5	1	291	11

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Eliminate from 1920.5 to 1498.5 because of minor folding	1920.5	..	..	..	..
The bed in center of anticline is mined for cement rock along the canal. This bed is 194 feet 9 inches above base of formation	1845.5	..	..	..	..
Axis of minor anticline	1765.5	..	..	..	..
Axis of minor syncline	1575.5	..	..	..	..
East end of stone and concrete retaining wall on south side of the railroad	1569.0	..	..	..	..
West end of short stone retaining wall south of the railroad, beginning at 1449.5 feet horizontally	1575.5	..	..	..	..
Axis of minor anticline	1515.5	..	..	..	..
Axis of minor syncline	1498.5	..	..	..	..
Interbedded argillaceous limestone and shale. This unit is exposed above level of track. It is best seen at 1920.5 feet horizontally	..	2	9	286	0
Highly contorted, dark-gray, argillaceous shale splitting at right angles to the bedding. (This unit is absent where the section is resumed farther west.)	1498.5	3	0	283	3
Green argillaceous sandstone	1490.0	2	0	280	3
Interbedded, thin-bedded, argillaceous limestone and gray fissile shale	1483.5	3	9	278	3
Thin-bedded, gray, fissile shale. *Leperditia alta* occurs throughout this unit	1477.5	1	2	274	6
Greenish, thick-bedded, arenaceous shale	1473.5	3	11	273	4
Argillaceous sandstone, breaking very irregularly	1459.0	1	0	269	5
Interbedded fissile shale and thin-bedded argillaceous limestone, middle 2 feet rotten. The top limestone is thicker-bedded	1457.0	8	2	268	5
East end of stone and concrete retaining wall on the south side of railroad	1449.5	1	0	260	3
Green, arenaceous shale, thin-bedded	..	0	10	259	3
Thick-bedded, arenaceous green shale, breaking irregularly. Part of underlying unit	1438.5	5	0	258	5
Red shale, breaking irregularly. *Leperditia alta* occurs throughout this unit	1422.0	1	8	253	5
Olive-green shale breaking irregularly. *Leperditia alta* occurs at top	1416.5	1	10	251	9
Thick-bedded arenaceous, calcareous shale weathering to a greenish-yellow tone	1408.5	1	0	249	11
Thin-bedded, banded, fissile calcareous shale	1403.5	0	10	248	11

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Thin-bedded purplish limestone and interbedded fissile shale	1400.5	4	9	248	1
Thick-bedded, hard, crystalline limestone somewhat siliceous, purplish tone, intersected by calcite seams. This bed contains *Cyathophylloid* coral, *Camarotœchia litchfieldensis* abundant, *Spirifer vanuxemi* abundant, *Hormatoma rowei*, *Calymene camerata*, *Leperditia alta*	1387.5	2	5	243	4
Thin-bedded, hard, somewhat siliceous limestone and interbedded shale. Lower 20 inches shale green like the underlying unit. *Leperditia alta* occurs in lower beds	1384.0	5	0	240	11
Arenaceous shale weathering to a greenish tone. Thicker-bedded than the underlying unit	1369.7	3	7	235	11
Thin-bedded, fissile, dark-gray, calcareous shale with a few thin bands of limestone. A calcite seam occurs 12 inches below top. *Leperditia alta* scattered sparsely throughout	1354.5	3	6	232	4
Thin-bedded, argillaceous limestone. *Leperditia alta* occurs at base. The base of the unit is at 1342.5 feet horizontally	1347.0	1	10	228	10
The section repeated between 1342.5 and 1120.5 horizontally	1342.5	..	..	..	..
A cement tunnel is opened at the level of the canal in a bed 194 feet 9 inches above base of the formation. The continuous section extending between 188 feet 9 inches to 202 feet 3 inches stratigraphically was measured at this place	1270.5	..	..	..	..
Axis of anticline	1255.5	..	..	..	..
Axis of syncline	1186.5	..	..	..	..
Axis of anticline	1170.5	..	..	..	..
West side of watchman's house	1168.8	..	..	..	..
Axis of syncline	1140.5	..	..	..	..
Sandstone, stained reddish-brown	1120.5	1	4	227	0
Thick-bedded, calcareous mud rock weathering to greenish tone	1115.5	5	6	225	8
Thin-bedded, banded, calcareous shale	1078.0	3	0	220	2
Hard, calcareous shale, weathering yellow	1074.0	1	8	217	2
Thin-bedded, dark, fissile shale. Thin bed of limestone 1 foot below top	1062.5	2	4	215	6

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Dark-gray, banded, calcareous shale, weathering to a greenish tone. Upper 4 inches brecciated. A light-colored band occurs near top	1055.5	3	10	213	2
Dark-gray, papery, calcareous shale with some thin bands of impure limestone in lower part. *Leperditia alta*, *L. brevicula* occur 2 feet 8 inches above base	1043.5	6	4	209	4
Dark-gray, thin-bedded limestone with a little interbedded, dark-gray shale	1026.5	0	9	203	0
The section exposed above track is much confused and is too thin, due to removal of cement rock. The section described below, between 188 feet 9 inches and 202 feet 3 inches stratigraphically is seen at the canal level where the section is normal. The exact point can be found by going 1270 feet horizontally on the track, then down bank at right angles to the track. A cement tunnel is driven in the unit at 194 feet 9 inches stratigraphically.					
Hard gray limestone conglomerate, consisting of numerous flat pebbles lying with their longer diameter parallel to bedding	1022.5	0	8	202	3
Banded, yellow limestone, with a few thicker magnesian beds 1 foot above the base. *Leperditia alta* occurs in the lower 13 inches	..	3	6	201	7
Fissile shale, nearly black (thickens on strike). *Leperditia alta* occurs 1 foot above base	..	1	6	198	1
Thick, yellow, magnesian limestone	..	1	10	196	7
Banded argillaceous shale, dark-gray, weathering yellow. A cement tunnel is driven in this unit at the tunnel level. Folding repeats this bed. Three tunnels are driven into it, one at 1270 feet horizontally at canal; a second at 1255 feet horizontally on track; a third at 1845 feet horizontally at canal	..	6	0	194	9
Section resumed at track level.					
Banded argillaceous limestone, stained yellow locally. A thin calcite seam in upper part. *Leperditia alta brevicula*, *Klœdenia normalis* occur at base	..	1	10	188	9
Dark-gray crinkled calcareous shale in very thin laminæ. Lower 2 feet somewhat thicker-bedded	986.0	5	0	186	11

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Thick-bedded, compact, argillaceous limestone, weathering gray; base at 962.5 horizontally	968.5	2	8	181	11
The section is repeated between 962.5 and 559.5 horizontally	962.5	..	..	..	..
Axis of minor anticline	925.5	..	..	..	..
Cement tunnel at 169 feet stratigraphically	920.5	..	..	..	..
West side of cement mill	616.0	..	..	..	..
Axis of minor syncline	605.5	..	..	..	..
Banded, calcareous shale in thin laminæ stained yellow, much crinkled	559.5	1	4	179	3
Thick-bedded, dark-blue calcareous mud rock, weathering brownish-yellow	558.0	8	10	177	11
Banded, fissile, argillaceous limestone in beds ⅛ to 1 inch thick. A calcite film ½ to 1 inch thick 4½ fet below top; projecting ledge 9 feet below top; breccia 3 feet above base. *Leperditia alta* occurs 2½ feet above the base. This unit is a cement rock. A tunnel was driven into it where it is repeated by folding at 920 feet horizontally. Another opening was also made at the level of the canal	541.8	15	5	169	1
Thick-bedded, dark-blue, argillaceous limestone and some interbedded calcareous shale weathering yellowish on surface	514.5	3	7	153	8
Thin-bedded, dark calcareous shale, with some interbedded limestone. A thick-bedded, greenish shale near the middle contains *Leperditia alta*	506.5	11	1	150	1
Thin-bedded, argillaceous limestone	488.2	1	9	139	0
Thin-bedded, dark-gray, fissile, calcareous shale with a few thin beds of argillaceous limestone	485.5	13	9	137	3
Thin-bedded, hard, dark-blue, argillaceous limestone	459.5	1	2	123	6
Greenish, arenaceous shale. Upper 1 inch thick-bedded, hackly	457.5	1	10	122	4
Very thick-bedded, calcareous shale, weathering yellow. This unit is seen south of the railroad track	455.5	3	5	120	6
Thin-bedded, fissile, gray shale, calcareous and banded. Upper half thicker-bedded, fissile and crinkled; lower part buff carrying *Leperditia alta*. Base of unit is at 434.2 feet horizontally	449.0	9	3	117	1

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Section repeated between 434.2 and 269.5 feet horizontally	434.2	..	..	..	..
Iron hook in wall of cut	367.5	..	..	..	..
Center of minor anticline	348.5	..	..	..	..
Center of minor syncline	278.5	..	..	..	..
Very thick-bedded, yellow, calcareous shale. *Leperditia alta* at top and 6 feet below top	269.5	10	6	107	10
Thick-bedded, calcareous shale. Middle 3 feet light-red, remainder greenish-yellow. This unit merges into underlying and overlying units	250.5	4	6	97	4
Calcareous shale. Lower 20 inches thin-bedded, banded, and gray with thin interbedded limestone; upper part thicker-bedded, banded, and yellowish to buff. Mud cracks are found on the upper surface of south wall of cut	244.5	6	2	92	10
Thick-bedded, arenaceous shale. Middle part red, remainder green. Uppermost 3 inches dark-gray fissile shale, a seam of calcite at top. *Leperditia alta* occurs at top	234.5	4	8	86	8
Dark-gray, thin-bedded shale. Upper part green. *Lingula* sp. occurs 1 foot below top	227.5	1	2	82	0
Thick-bedded gray shale weathering buff-colored with brown stains	225.8	10	1	80	10
Thick-bedded, gray, calcareous shale, weathering greenish-yellow. Lower part thinner-bedded and darker. Upper part similar to overlying unit. Beds are banded. *Leperditia alta* 1 foot below top	208.9	4	0	69	11
Thin-bedded, dark-gray, argillaceous shale containing calcite seams. *Leperditia alta* occurs at top	202.8	2	0	65	11
Thick-bedded, arenaceous shale, alternating green and red beds. This unit becomes somewhat yellowish at top, the upper 2 inches very arenaceous. *Leperditia alta* and *Lingula* sp. occur 2 feet and 7½ feet below top of unit. *Lingula* sp. also occurs 8 feet 8 inches below top of unit	198.5	19	7	63	11
Bloomsburg Sandstone Member					
Massive red sandstone. Banded with green lines in lower part	168.1	11	3	44	4
Thick-bedded, arenaceous red shale. Green lines at right angles to the bedding plane	143.1	7	0	33	1

	Horizontal distance from beginning of traverse to top of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Thin-bedded shale, green below, red above....	130.1	3	2	26	1
Hard, gray quartzitic sandstone. Thickness varies from a few inches to 1 foot..........	120.5	0	6	22	11
Thin, greenish, fissile shale much crushed. Varies in thickness from 8 inches to 2 feet.....	120.5	1	0	22	5
The remainder of the section was measured near the cut through the eastern anticline.					
Thick-bedded, red, arenaceous shale, containing in its lower 2 feet, light-colored calcareous nodules arranged in vertical lines. These when dissolved give rise to a porous rock. Top discolored green; upper part streaked with vertical green lines and containing nodules which are often green. (Top seen in center of western anticline.).......	117.5	12	3	21	5
Red shaly sandstone containing green lines at right angles to the bedding................	82.5	4	4	9	2
Thick-bedded, red shale, breaking irregularly. This unit runs parallel to the track for some distance.................................	52.5	2	6	4	10
Thick-bedded, red, argillaceous sandstone. Lower 6 inches contain alternating red and green bands	7.5	2	4	2	4
Thickness of Wills Creek formation....				487	7
McKENZIE FORMATION					
Arenaceous shale, weathering green..........	..	1	0	10	4
Thin-bedded, gray shale somewhat arenaceous.	..	2	7	9	4
Thick-bedded, arenaceous shale weathering to a greenish tone	..	4	0	6	9
Gray, argillaceous shale exposed at western end of the eastern cut.....................	..	2	9	2	9
Thickness of McKenzie formation described				10	4

XII. Section at Grasshopper Run, West Virginia

Grasshopper Run is a small stream that enters the Potomac River from the south about 1½ miles west of Hancock where it is crossed by the Baltimore and Ohio Railroad. The Keefer sandstone member of the Rochester formation outcrops west of the stream, while the Bloomsburg sandstone caps the summit of a small knob immediately east of the run and south of the Baltimore and Ohio Railroad tracks. The Wills Creek and Tonoloway formations are exposed in the cuts of the railroad east of the run. The strata of the Wills Creek formation disintegrate readily upon exposure to the weather, so that all save its more resistant rocks are covered with vegetation. The Tonoloway formation, on the contrary, consists of much more resistant beds which are finely exhibited in the railroad cuts farther east.

The section begins at the Helderberg-Tonoloway contact which is situated 2,553 feet east of the center of the railroad culvert over Grasshopper Run.[1] The massive, nodular, highly fossiliferous beds of the Keyser limestone are finely exposed in the cliff at this point, contrasting greatly with the thin-bedded, fissile, platy, sparingly fossiliferous strata of the immediately underlying Tonoloway. The section described extends westward along the tracks, terminating on the railroad at a heavy ledge of sandstone, 975 feet east of the center of the culvert over Grasshopper Run. Still lower beds are exposed on the cliff above the sandstone ledge. A purple and green shale, seen at the latter point, lies 698 feet stratigraphically below the top of the Tonoloway. It is believed to be the same stratum as the red bed observed in the section at Round Top, 375 feet stratigraphically above the base of the Wills Creek formation. If such is the case the thickness of the combined Wills Creek and Tonoloway formations is 1,073 feet comparing very closely with the thickness, 1,062 feet, assigned to the same formations at Pinto.

This exposure, in connection with that at Round Top, affords a section which embraces all of the Wills Creek and Tonoloway formations and is second only to that seen at Pinto.

An interesting feature is the occurrence of imprints of cubical crystals, presumably salt crystals, in the shales, 464 feet below the top of the Tonoloway formation. The lower beds of the Tonoloway formation are much more argillaceous than corresponding strata of the western sections, where heavy beds of limestone form the base of the formation.[2]

[1] The horizontal measurements were made along the railroad tracks. The thicknesses of the beds were measured directly.

[2] Measured by C. K. Swartz assisted by R. Leibensperger. The horizontal traverse begins at the Tonoloway contact.

HELDERBERG FORMATION

Keyser Limestone Member

	Horizontal distance from beginning of traverse to base of beds	Thickness — Beds		Thickness — Total	
	Feet	Feet	Inches	Feet	Inches
Very massive, nodular limestone, highly fossiliferous, containing *Stropheodonta* (*Leptostrophia*) *bipartita* var. *curviradiata*, *Camarotœchia litchfieldensis* abundant, *Schuchertella interstriata*, *Spirifer vanuxemi* var. *tonolowayensis* abundant, *Halliella fissurella* abundant, *Tentaculites gyracanthus* var. *marylandicus*, *Klœdenella medialis*, *K. germana*	..	..	..	..	..

TONOLOWAY FORMATION

	Feet	Feet	Inches	Feet	Inches
Hard, dark-gray crystalline limestone, not distinctly nodular, containing light-colored flattened pebbles at its base. Conspicuously exposed on the cliff. This unit contains *Stropheodonta* (*Leptostrophia*) *bipartita* var. *curviradiata*, *Schuchertella interstriata*, *Camarotœchia litchfieldensis* abundant, *Spirifer vanuxemi* var. *tonolowayensis* abundant, *Spirifer keyserensis* abundant. May be Keyser.	.	1	10	596	6
Very argillaceous arenaceous limestone, weathering greenish. This unit contains so much sand that some beds are almost sandstone..	38.0	3	0	594	8
Thin-bedded, platy, argillaceous limestone weathering blue. The lower 9 inches are somewhat thicker-bedded	70.0	4	8	591	8
Shaly, argillaceous limestone weathering into thin plates ¼ to 1 inch thick. *Camarotœchia litchfieldensis* occurs 18 inches above the base of unit	166.0	14	0	587	0
Thick-bedded, calcareous breccia containing calcite films	167.0	0	7	573	0
Blue, argillaceous lenticular limestone	..	0	3	572	5
Thin-bedded, fissile, calcareous shale	192.0	5	0	572	2
Concealed in part. Largely calcareous shale. N. 27° E. 41° E. Telegraph pole No. 124-24 at 218 feet horizontally. Pole No. 124-25 at 331 feet horizontally	485.0	93	1	567	2
Platy, argillaceous limestone	..	3	0	474	1
Platy limestone and interbedded calcareous shale	562.0	16	6	471	1

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Telegraph pole No. 124-27	562.0	..	..	..	..
Concealed in part. This unit probably consists largely of calcareous shale	..	43	11	455	7
Laminated, shaly limestone seen above an iron stake	..	4	7	411	8
Iron stake, 8 feet above the track	676.0	..	..	..	..
Laminated shaly limestone, seen far above the track west of telegraph pole No. 124-28	..	3	7	407	1
Magnesian limestone, breaking irregularly. Concealed at track level	..	0	10	403	6
Yellow, calcareous shale. Exposed at pole No. 124-28	..	0	8	402	8
Thin-bedded, laminated bluish limestone	..	4	0	402	0
Yellowish limestone in a single course, breaking irregularly	..	1	0	398	0
Thin-bedded, argillaceous laminated limestone	..	8	0	397	0
Limestone, upper part heavy-bedded, lower thinner-bedded. Poorly seen at track level.	683.0	1	9	389	0
Laminated limestone, heavy-bedded with a thin bed of yellowish limestone above base. The base of this unit is the top of a cave	694.0	4	9	387	3
Laminated limestone; 20 inches below the top of this unit is the floor of cave	702.0	3	6	382	6
Thick-bedded, non-laminated limestone, yellowish color, breaking irregularly	706.0	1	10	379	0
Thin-bedded, fissile, calcareous shale	707.0	0	5	377	2
Laminated, blue limestone in courses ¼ to 1 inch thick with occasional thicker layers. *Camarotœchia litchfieldensis* var. *marylandica* common, and *Hindella congregata* occur 10 feet above the base. *Leperditia alta* occurs 9 feet and 7 feet above base. *Camarotœchia litchfieldensis, Lioptera pennsylvanica* ?, *Modiolopsis gregarius, Leperditia alta* occur 4 feet above base. *Camarotœchia litchfieldensis* var. *marylandica* abundant, *C. litchfieldensis, Hindella congregata, Leperditia alta* occur 2 feet above base	740.0	13	0	376	9
Dark-gray limestone in a single bed above, laminated limestone below	..	2	1	363	9
Thick-bedded limestone, breaking irregularly and weathering yellowish	745.0	1	8	361	8
Section concealed along track.					

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Section is continued above track level west of pole 124-29.					
Calcareous shale and thin-bedded, laminated limestone	746.0	0	10	360	0
Laminated limestone containing one heavier bed. Shaly below	..	2	0	359	2
Fissile calcareous shale passing in upper part into a shaly limestone. Part of this unit is concealed	760.0	4	0	357	2
Argillaceous limestone, breaking irregularly.	..	1	2	353	2
Laminated limestone rather thick-bedded with 3 inches of calcareous shale at base	765.0	1	9	352	0
Laminated, hard, blue limestone, rather thick-bedded. Non-resistant to weathering	772.0	4	3	350	3
Thin-bedded, shaly, laminated limestone breaking into beds ¼ to ¾ inch thick. *Leperditia alta* occurs in the upper 4 feet. Pole No. 124-29	793.0	6	2	346	0
Thicker-bedded, laminated limestone 6 inches thick containing *Leperditia alta* at base	..	3	9	339	10
Thin-bedded, laminated limestone, lower 2 feet shaly; containing *Leperditia alta*	..	13	6	336	1
Thick-bedded, magnesian limestone, weathering yellow	..	0	10	322	7
Calcareous shale weathering yellow	..	2	0	321	9
Thick-bedded, blue crystalline limestone containing *Hindella congregata, Dizygopleura simulans, D. halli, Welleria oblique*	..	1	0	319	9
Thin-bedded, somewhat nodular limestone. Unit exposed on cliff at level of top of pole No. 124-30. *Leperditia alta* occurs throughout unit	..	2	9	318	9
Massive, gray, crystalline limestone. *Leperditia alta* occurs throughout	..	4	0	316	0
Thinner-bedded, gray limestone weathering yellow and overlain by some shale. The lower 5 inches are quite yellow. *Camarotœchia litchfieldensis* and *Leperditia alta* occur at top. *Camarotœchia litchfieldensis, Camarotœchia tonolowayensis, Hindella congregata* and *Cornulites* sp. occur near base.	..	1	3	312	0
Laminated blue limestone	..	3	3	310	9
Yellow magnesian limestone with some interbedded shale, irregular fracture	..	1	4	307	6

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Limestone, somewhat laminated. The lower 4 feet contain dark, crystalline bands with lighter ones. Numerous bands appear highly fossiliferous but fossils are obtained with difficulty. Two feet 6 inches above the base occur *Hindella congregata*, *Hormatoma rowei*. *Leperditia alta*, *Dizygopleura halli* are found in the lower 4 feet.............	..	10	0	306	2
Thick-bedded, blue limestone. Light-colored limestone fragments in the lower part......	..	1	8	296	2
Laminated, fissile, shaly limestone...........	..	1	7	294	6
Thick-bedded, magnesian limestone..........	..	1	9	292	11
Laminated limestone. The lower 18 inches are heavier-bedded and contain black chert nodules. Pole at 897 feet....................	897.0	4	0	291	2
Thin-bedded laminated, shaly limestone. The section is resumed along the railroad track..	907.0	5	8	287	2
Thick-bedded magnesian limestone. Lower foot breaks irregularly and weathers yellow. This unit is exposed 10 feet west of pole 124-30	910.0	2	0	281	6
Thin-bedded, laminated shaly limestone. One foot above the base occur *Welleria obliqua*, *Dizygopleura halli*, *D. simulans*, *Leperditia scalaris praecedens*	924.0	6	9	279	6
Hard, blue limestone in a single course.......	..	5	5	272	9
Thin-bedded, somewhat nodular limestone. *Camarotœchia litchfieldensis*, *Hindella congregata*, *Hormatoma rowei*, *Leperditia alta* occur 18 inches below the top.............	935.0	4	6	272	4
Thick-bedded, gray, crystalline limestone.....	936.0	1	3	267	10
Medium-bedded limestone with some interbedded shale. The lower 4 feet break irregularly and weather yellow................	947.0	4	8	266	7
Interbedded calcareous shale and shaly limestone. The lower part is somewhat lumpy. *Camarotœchia litchfieldensis*, *C. tonolowayensis*, *Uncinulus marylandicus*, *Leperditia alta*, occur in the lower foot. About this unit were collected *Solenospira minuta* ?, *Orthoceras* sp., *Camarotœchia litchfieldensis*, *Hindella congregata*	953.0	4	4	261	11

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Massive gray crystalline limestone. Near top occur *Hindella congregata, Leperditia alta, Welleria obliqua, Dizygoplcura halli, D. simulans, D. subovalis*	958.0	2	6	257	7
Very thin-bedded, calcareous shale	960.0	0	11	255	1
Dark-blue limestone made of Stromatoporoids.	963.0	1	6	254	2
Blue laminated limestone. Middle beds more shaly; upper and lower beds hard and thicker-bedded	987.0	13	5	252	8
Hard, dark-blue magnesian limestone	988.0	1	4	239	3
Thin-bedded, laminated limestone weathering into layers ½ to 1 inch thick. Beds slightly nodular. *Hindella congregata, Leperditia alta* occur near base	992.0	7	5	237	11
Massive gray, crystalline limestone. The base somewhat yellow. *Hindclla congregata, Leperditia alta* occur near base	1005.0	1	5	230	6
Laminated limestone passing into calcareous shale at upper and lower limits. Pole at 1011 feet	1010.0	3	10	229	1
Magnesian limestone breaking irregularly and weathering yellow	1011.0	0	7	225	3
Laminated limestone. Upper part shaly, lower part thicker-bedded	1020.0	4	8	224	8
Dark-blue, crystalline limestone in one course containing *Hindella congregata*	1022.0	0	9	220	0
Shaly, laminated argillaceous limestone	1024.0	1	4	219	3
Laminated, argillaceous limestone and interbedded shale. Mud cracks on lower surface.	1033.0	3	8	217	11
Laminated limestone and interbedded shale. The lower 9 inches are one single bed. Upper bed eroded	1045.0	6	7	214	3
Laminated, shaly limestone	1055.0	4	4	207	8
Laminated limestone, lower part thin-bedded.	1065.0	5	6	203	4
Thick-bedded gray crystalline limestone containing *Hindella congregata, Leperditia alta* abundant, *Solenospira minuta*	..	4	9	197	10
Laminated limestone containing *Hindella congregata* abundant, *Camarotœchia litchfieldensis, Uncinulus marylandicus* abundant, *Camarotœchia tonolowayensis, Hormatoma rowei*	1090.0	7	0	193	1

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Limestone in two heavy courses with a shale layer above and below. In the upper foot occur *Hindella congregata*, *Leperditia alta*, *Welleria obliqua*, *Dizygopleura simulans*....	..	..	..	..	..
Thin and medium-bedded limestone..........	1109.0	6	0	182	5
Heavy bed of limestone....................	1111.0	1	2	176	5
Thin-bedded, shaly limestone. Beds irregular, lower foot heavy-bedded. In the lower half of this unit occur *Camarotœchia tonolowayensis*, *Hindella congregata*, and *Leperditia alta*	1139.0	16	8	175	3
Pole No. 123-32	1139.0	..	..	..	..
Thin-bedded argillaceous limestone and interbedded shale. This unit begins a reentrant cut	1155.0	6	0	158	7
Travertine and clay. Seen in reentrant cut west of pole No. 124-32..................	1156.0	1	0	152	7
Thick-bedded, argillaceous limestone. The lower part weathers yellow and breaks irregularly	1162.0	4	0	151	7
Thin-bedded laminated limestone with some thicker beds 5 feet above base. Near base of unit occurs *Leperditia alta*.............	1173.0	7	5	147	7
Shaly argillaceous limestone weathering into thin beds. Upper 2 feet are heavier-bedded. Four feet above the base of unit occur the impressions of cubical crystals, presumably salt crystals	1199.0	11	6	140	2
Hard, gray crystalline limestone. *Leperditia alta*	..	0	10	127	8
Very argillaceous, thick-bedded magnesian limestone almost a mud rock.............	1206.0	4	6	126	10
Fissile calcareous shale with abundant *Leperditia alta* at base........................	1220.0	5	10	122	4
Thick-bedded mud rock, lower part very arenaceous	1223.0	2	2	116	6
Massive sandstone	1230.0	5	3	114	4
Interbedded calcareous shale and thin limestone	1233.0	2	0	109	1
Laminated limestone with some calcareous shale	1235.0	1	6	107	1
Magnesian limestone	..	0	7	105	7
Calcareous shale and shaly limestone........	1253.0	3	5	105	0
Magnesian limestone	1254.0	1	0	101	7

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Fissile shaly limestone and calcareous shale. Upper 2 feet yellowish, probably somewhat magnesian. Last of the beds in reentrant cut, first in the track cut	1267.0	9	6	100	7
Soft yellow magnesian limestone, shaly below	1268.0	0	6	91	1
Interbedded thin limestone and calcareous shale	1271.0	2	7	90	7
Magnesian limestone	..	0	9	88	0
Interbedded fissile shale and thin limestone with a rotten yellow band 6 inches above the base. Near the base of this unit occurs *Leperditia alta*	1294.0	11	7	87	3
Magnesian limestone	1296.0	1	5	75	8
Calcareous shale with some thin-bedded laminated limestone. Near base of unit occurs *Leperditia alta*	1314.0	9	8	74	3
Hard, medium-bedded laminated limestone with some thinner beds. *Leperditia alta* occurs throughout the upper part	1325.0	6	0	64	7
Rotten, yellow calcareous shale	1331.0	1	3	58	7
Calcareous shale with some interbedded thin-bedded argillaceous limestone. Near the middle of this unit occurs *Leperditia alta*	1365.0	21	6	57	4
Hard, blue limestone. Upper part thinner-bedded	1371.0	2	2	35	10
Calcareous shale	..	0	6	33	8
Compact crystalline limestone. Lower 4 feet a limestone conglomerate consisting of light-colored fragments in a darker groundmass. One foot 7 inches above base occur *Schuchertella rugosa* (?), *Camarotœchia litchfieldensis*, *Spirifer vanuxemi*, *Leperditia alta*	1374.0	2	1	33	2
Calcareous shale	..	0	6	31	1
Laminated argillaceous magnesian limestone weathering yellow. Base of unit 9 feet east of pole No. 124-34	1380.0	2	10	30	7
Pole No. 124-34	1389.0	..	..	..	..
Interbedded fissile calcareous shale and thin-bedded argillaceous limestone. Lower 2 feet contain *Leperditia alta*	..	4	7	27	9
Thin-bedded, hard blue limestone in beds ½ to 1½ inches thick with some interbedded shale weathering bluish-gray, containing *Leperditia alta*	1393.0	2	10	23	2

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Shale and limestone. Six inches of calcareous shale at top, 8 inches hard blue limestone in middle, and 4 inches of shaly blue limestone at bottom	..	1	6	20	4
Fissile, calcareous, very argillaceous shale weathering yellow. A band of hard blue limestone 3 inches thick at base	1405.0	4	9	18	10
Calcareous shale with some thin beds of magnesian limestone 2 to 3 feet below top of unit. Thinner beds of limestone occur in lower part	1414.0	5	4	14	1
Hard blue limestone. At bottom flattened limestone pebbles	1417.0	1	10	8	9
Dense blue oölitic crystalline limestone in a single course, containing some limestone pebbles	..	0	7	6	11
Thin, fissile, calcareous shale	1433.0	2	6	6	4
Massive limestone. Top compact and deep-blue. Bottom oölitic	..	2	6	3	10
Laminated limestone weathering yellowish. Thinner-bedded above. Compact at base	..	1	4	1	4
Total thickness of Tonoloway formation				596	6

WILLS CREEK FORMATION

Calcareous shale	..	3	6	3	6
Concealed. The thickness of this unit was determined by running a traverse at right angles to the strike from the top of the preceding bed to the base of the sandstone at 82.5 stratigraphic feet, assuming a dip of 40° E.	1510.0	40	9	44	3
Hackly, green shale	..	1	10	46	1
Concealed. Some thin-bedded limestone	1517.0	1	6	47	7
Dark, fissile somewhat arenaceous shale with laminated yellow limestone at base	1519.0	3	10	51	5
Concealed. Some thin-bedded argillaceous limestone	1529.0	2	8	54	1
Fissile shale. Upper 18 inches breaks irregularly	1542.0	5	9	59	10
Blue crystalline limestone	1543.0	1	2	61	0
Shale	1545.0	1	4	62	4
Interbedded shale and thin-bedded argillaceous limestone	1550.0	2	10	65	2

	Horizontal distance from beginning of traverse to base of beds	Thickness			
		Beds		Total	
	Feet	Feet	Inches	Feet	Inches
Arenaceous green shale breaking very irregularly	1561.0	5	10	71	0
Shale breaking into thin plates. A thin limestone band 3.5 feet above base	1580.0	10	2	81	2
Medium-bedded argillaceous limestone	1582.0	1	4	82	6
Compact brown sandstone. Upper 18 inches sand layers in limestone	1588.0	5	0	87	6
The remainder of the section is exposed above level of the railroad near the top of cut.					
Arenaceous shale with 3 inches of sandstone at the base	..	2	3	89	9
Arenaceous green shale breaking irregularly	..	3	2	91	11
Hard brown sandstone	..	0	8	93	7
Interbedded arenaceous shale and sandstone bands	..	3	4	96	11
Arenaceous green shale breaking irregularly	..	4	3	101	2
Green and purple shale	..	2	0	103	2
Rotten, calcareous shale	..	1	0	104	2
Arenaceous shale with a band of limestone at the base	..	2	0	106	2
Interbedded arenaceous shale and thin sandstone above, laminated limestone and interbedded shale below containing *Leperditia alta*	..	12	0	118	2
Concealed.					
Thickness of Wills Creek formation described				118	2

XIII. Section on Log Road East of Grasshopper Run

A log road crosses Grasshopper Run 1050 feet south of the Baltimore and Ohio Railroad tracks and leads up the mountain towards the east. The lower part of the Wills Creek formation is seen along the road supplementing the section described along the railroad. The Bloomsburg sandstone is finely exposed at its base. Two hundred and twenty-five feet stratigraphically (271 feet horizontally) above the base of the formation is a limestone containing *Camarotœchia litchfieldensis* and *Spirifer vanuxemi* in abundance, associated with *Calymene camarata.* This horizon is of interest as showing the widespread persistence of this faunule.

XIV. Section at Hancock

Two small quarries are worked along the Valley Road west of Hancock, the Keyser limestone being quarried east of the road, the Tonoloway west of the road. The Tonoloway-Helderberg contact is seen at the base of the eastern quarry.

A conspicuous feature of the Tonoloway, seen in the western quarry, is the thick Stromatopora reef which occupies the same stratigraphic position as the similar reef at Grasshopper Run, West Virginia, and hence is valuable for correlation.

D. Sections in Fairview Mountain Anticline

Two subordinate anticlines, Cross Mountain and Hearthstone Mountain, lie west of Fairview Mountain. The first of the following sections is in the Cross Mountain anticline; the second is exposed in the Hearthstone Mountain anticline.

XV. Section Northwest of Indian Spring

The best exposure of the Tonoloway formation observed in the North Mountains of Maryland is found on the south bank of Lanes Run, 1½ miles, in air line, above its junction with Licking Creek and the same distance from Indian Spring. The base of the section is exposed on the south bank of the run 800 feet N. 75° W. from the point where the county road crosses the run. The top of the section is just east of a small quarry which is situated on the south bank of the run, 1000 feet east of the intersection of the road and the run.[1]

TONOLOWAY FORMATION	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
The following section is seen in a cliff east of the quarry.			
Top of cliff	..	..	..
Concealed	..	7.0	277.6
Argillaceous laminated limestone	..	2.0	270.6

[1] The horizontal traverse begins at the top of a cliff situated 50 feet stratigraphically above the base of the section. Measured with tape by C. K. Swartz assisted by G. M. Hall and G. Taylor.

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed. Some beds of argillaceous laminated limestone exposed at top	..	10.7	268.6
Section is continued in small quarry south of Lanes Run.			
Thin to medium-bedded laminated limestone at top of the quarry. At its base occurs *Camarotœchia tonolowayensis*. *Hindella congregata* is abundant throughout	..	5.0	257.9
Calcareous shale with a bed of compact blue limestone 5 inches thick, 1 foot above base	..	3.0	252.9
Hard, dark-blue limestone breaking irregularly, forming a single course	..	1.3	249.9
Calcareous shale above, compact blue limestone at base	..	1.3	248.6
Hard, blue limestone. Finely laminated weathering into thin plates	..	5.5	247.3
Calcareous shale weathering to a greenish tone	..	1.2	241.8
Blue argillaceous limestone. Upper 3 feet medium-bedded, remainder finely laminated. At its base occurs *Leperditia alta*	..	10.6	240.6
Massive, hard, dark-blue limestone with some calcite streaks; contains solution cavities, more or less porous. At top occur *Camarotœchia tonolowayensis* and *Leperditia alta*	..	2.1	230.0
Soft calcareous shale becoming drab on weathering, containing a few small hard limestone laminæ	..	1.3	227.9
Arenaceous, laminated, hard gray limestone, thinner-bedded below, containing *Camarotœchia tonolowayensis*	..	4.2	226.6
Crystalline limestone underlain and overlain by argillaceous layers, containing many *Camarotœchia tonolowayensis*	..	0.6	222.4
Dark-blue limestone, upper foot resistant; lower shaly, containing *Leperditia alta*. This bed forms a projecting ledge west of the quarry and is the lowest bed exposed in ravine west of the quarry. The top of this bed also outcrops 21 feet above the base of the cliff (1516 feet horizontally)	..	2.0	221.8
Center of small ravine entering Lanes Run from south	1636.0	..	..
The section is continued in the cliff situated 170 feet west of the ravine.			

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Platy blue limestone, weathering gray, in beds ½ to 1 inch thick. Three feet above base of unit occur various ostracods. *Hindella congregata* occurs 1.4, 2.8 abundant, 3.9 abundant, 5, and 9.5 feet above base. *Leperditia alta* occurs 2.8, 6, 7, and 9.5 feet above base	..	13.8	219.8
Thin-bedded, laminated argillaceous limestone. Lower layers crystalline, upper beds shaly. The top of this unit is 7 feet above the base of the cliff. At the base of the unit occur *Camarotœchia tonolowayensis*, *Hindella congregata*, *Hormatoma rowei*, *Leperditia alta*, and various ostracods	..	..	..
One foot above its base occurs *Modiolopsis* sp., and *Camarotœchia tonolowayensis*	..	5.2	206.0
The section is continued in the cliff, back of a spring, 1231.			
Hard, dark-blue limestone forming a single course at the top of the wash back of the spring. It contains *Leperditia alta*	..	1.0	200.8
Thin-bedded, argillaceous limestone, somewhat nodular, weathering blue	..	1.2	199.8
Concealed	..	1.9	198.6
Heavy-bedded, compact, dark-blue limestone	..	2.2	196.7
Shaly limestone. Much weathered	..	1.0	194.5
The section is continued in the cliff in rear of dwelling.			
Medium to thick-bedded, compact, light-blue limestone. Two feet 5 inches below top occurs *Leperditia alta*.	..	3.0	193.5
Laminated argillaceous limestone. Three feet 5 inches below top occur *Camarotœchia tonolowayensis*, *Modiolopsis* sp., *Leperditia alta*	..	8.3	190.5
The section is continued in rear of dwelling.			
Concealed	..	19.2	184.2
Thin-bedded argillaceous limestone containing *Leperditia alta*	..	0.7	165.0
Concealed	..	3.5	164.3
Very argillaceous limestone, thin-bedded to laminated. *Leperditia alta* throughout	..	5.0	160.8
Calcareous shale. This unit contains *Leperditia alta*.	..	0.5	155.8
Concealed largely. In some very argillaceous laminated limestone occur *Leperditia alta*	..	8.5	155.3
Dwelling house	1006.0	..	..

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
The section is exposed along a lane leading eastward from dwelling.			
Laminated, crystalline limestone somewhat arenaceous, very fossiliferous containing *Leperditia alta*, *Camarotœchia tonolowayensis*	..	2.5	146.8
Arenaceous green shale..........................	..	7.2	144.3
The section is seen in a small wash on the hillside, west of the dwelling. This exposure is 170 feet S. 55° W. from the point where the county road crosses Lanes Run	706.0	..	..
Medium to thick-bedded sandstone. N. 62° E. 9° E. This bed is the same as that exposed 356 feet horizontally	..	4.7	137.1
Red, argillaceous sandstone, medium to thick-bedded.	..	1.3	132.4
Greenish, argillaceous sandstone above, becoming red below	..	1.4	131.1
Thick-bedded, green sandstone....................	..	2.9	129.7
Red, arenaceous shale	..	1.2	126.8
Thick-bedded green sandstone.....................	..	3.7	125.6
The traverse is continued eastward along the top of the outcropping ledge of sandstone for a distance of 350 feet, no strata are crossed.................	..	..	137.1
The section is continued on hillside south of Lane's Run. The traverse ascends the hill from top of the massive limestone which forms a cliff at the base of the Tonoloway formation.			

Traverse S. 4° W.

Massive sandstone white and very hard. Its base is 75 feet above top of cliff..........................	356.0	14.5	137.1
Concealed. Traverse crosses county road 42 feet vertically above top of cliff........................	291.0	116.0	122.6
The following section is exposed on the south bank of Lane's Run east of the limestone cliff, at the base of the Tonoloway formation. The beds here exposed form a part of the concealed unit described above.			
Massive limestone. Seen only in one place..........	..	1.0	32.5
Medium-bedded, very argillaceous limestone.........	..	6.4	31.5
Thin-bedded, shaly limestone......................	..	2.8	25.1
Massive blue limestone above. Medium-bedded calcareous shale 1 foot thick at base................	..	1.8	22.3
Yellow mud rock..................................	..	0.2	20.5

	Horizontal distance from beginning of traverse to top of beds Feet	Thickness Beds Feet	Thickness Total Feet
Massive, dark-blue limestone	..	1.2	20.3
Thin-bedded gray calcareous shale, partly concealed	..	12.5	19.1
Very massive, hard, dark-gray limestone, becoming gray on weathering. This bed forms a prominent cliff on the south side of Lane's Run just opposite a dwelling. Dip 10½° E	..	..	..
The traverse ascends the hill from the top of this ledge	..	6.6	6.6
Thickness of Tonoloway formation exposed			277.6

WILLS CREEK FORMATION

The section is exposed on the south bank of Lane's Run west of the cliff described above.

Traverse S. 73° E.

Calcareous shale and shaly limestone above. Impure limestone, thick-bedded, weathering yellow, below	..	1.5	..
Concealed	..	7.0	43.4
Massive, hard blue limestone in a single course	..	1.3	34.9
Thin-bedded limestone and calcareous shale	..	0.7	33.6
Calcareous shale and shaly limestone. Concealed in part	..	11.2	24.4
Argillaceous limestone and some interbedded calcareous shale	..	1.3	13.2
Calcareous shale somewhat arenaceous and some interbedded argillaceous, thin-bedded limestone	..	3.9	11.9
Arenaceous shale	..	8.0	8.0
Concealed west of this point	..	..	..
Thickness of Wills Creek formation described			43.4

XVI. Section West of Clearspring, Maryland

An excellent section of the Wills Creek formation is exposed in a ravine occupied by a small branch, which enters Lanes Run from the east, 3.5 miles N. 77° W. from Clearspring.[1] The section described begins at the base of a heavy ledge of sandstone which outcrops on the hill south of the

[1] A county road leads northward and crosses this branch 250 feet north of latitude N. 39° 40′ of the topographic map.

bridge over the stream and terminates at the McKenzie-Wills Creek contact in the ravine, 1697 feet southeast of the bridge.[1]

TONOLOWAY FORMATION

Section exposed on the hill south of the bridge.

Traverse N. 22° W.	Horizontal distance from center of bridge to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
Massive white sandstone exposed on hill-top west of county road	..	..	..
WILLS CREEK FORMATION			
Concealed. The position assigned the Wills Creek-Tonoloway contact is approximate only. The base of this unit is 675 feet horizontally and 48 feet vertically below the base of the sandstone on hill..	..	50.0	614.3
Traverse S. 47° E.			
Arenaceous gray shale	..	1.2	564.3
Interbedded shale and sandstone, N. 5° E. 27° W. (average of 3 measurements)	281.0	2.1	563.1
Hard blue limestone. Single course	..	0.2	561.1
Arenaceous gray shale weathering greenish	294.6	2.0	560.8
Arenaceous shale. Reddish tone	..	1.5	558.8
Green arenaceous shale. Lower 7 inches argillaceous sandstone. Forms ledge in stream. Dip about 20° W.	309.0	5.5	557.3
Red arenaceous shale	323.0	3.5	551.8
Greenish arenaceous shale	326.5	2.0	548.3
Concealed	389.5	20.0	546.3
Green arenaceous shale. Some sand grains	..	3.5	526.3
Red arenaceous shale	423.0	6.1	522.8
Fissile green shale above, red arenaceous shale 0.8 feet thick at base, unit partly concealed	478.0	5.4	516.7
Green argillaceous sandstone. Upper 2.7 feet very massive. Strike due N. Dip 27° W. and 54° W	..	4.0	511.3
Green shale	..	3.9	507.3
Red shale rather thin-bedded	..	4.5	503.4
Very arenaceous red shale, upper part almost a sandstone	..	4.5	498.9

[1] Measured with tape by G. M. Hall under the direction of C. K. Swartz. The horizontal traverse begins at the center of a small bridge over the branch and extends thence southeast up the ravine.

	Horizontal distance from center of bridge to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
Fissile green shale	..	0.5	494.4
Heavy-bedded sandstone, yellow on fresh fracture	..	2.6	493.9
Heavy-bedded, arenaceous red shale	..	4.0	491.3
Argillaceous red sandstone	..	1.5	487.3
Medium-bedded red shale	..	0.5	485.8
Red shale, very fissile in direction of schistosity	..	3.5	475.3
Heavy-bedded, argillaceous red sandstone. Dip 35° W.	570.0	4.0	481.8
Concealed. Soil red	611.0	18.0	477.8
Green shale, slight red mottling	..	3.5	459.8
Impure argillaceous limestone with some shale	..	2.5	456.3
Green and red arenaceous shale	624.0	4.0	453.8
Axis of minor anticline, probably a fault	624.0	..	..
Traverse S. 66° E.			
Impure argillaceous limestone with some shale	..	2.5	..
Greenish shale	633.0	3.5	..
Axis of minor syncline	633.0	..	..
Massive sandstone yellowish on fresh fracture	..	3.4	449.8
Arenaceous shale	..	0.5	446.4
Massive, argillaceous sandstone	647.0	1.5	445.9
Fissile greenish shale. Dip approximately 35° W.	..	6.4	444.4
Argillaceous limestone. Seen in stream bed	..	2.0	438.0
Concealed	689.0	15.0	436.0
Red shale	..	3.3	421.0
Gray, argillaceous sandstone in beds about 4 inches thick. Dip 50° W.	..	1.7	417.7
Massive red sandstone	705.0	3.5	416.0
Concealed	743.0	22.0	412.5
Very arenaceous gray shale, almost a sandstone, seen in stream	754.0	4.5	390.5
Concealed. At 25 feet above base (776 horizontal) a sandstone	826.0	43.0	386.0
Crinkly limestone with calcite veins	..	3.4	343.0
Massive sandstone. Dip 75° W.	..	4.5	339.6
Red arenaceous shale	..	3.5	335.1
Green arenaceous shale	843.0	0.7	331.6
Concealed	847.0	3.0	330.9
Hard blue impure limestone	848.0	0.8	327.9
Concealed	862.0	10.0	327.1
Sandstone in course 2 to 4 inches thick	..	1.5	317.1
Massive sandstone	..	1.4	315.6
Shaly sandstone. More shaly at base	869.0	2.0	314.2
Concealed	873.0	3.0	312.2

	Horizontal distance from center of bridge to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
Banded limestone in stream bed. Dip 75° W.	879.0	4.5	309.2
Concealed	887.0	5.0	304.7
Green argillaceous sandstone, forming a projecting point	..	0.8	299.7
Red arenaceous shale	..	4.0	298.9
Green arenaceous shale	903.0	5.5	294.9
Concealed	909.0	4.0	289.4
Blue limestone forming a ledge in the stream	..	2.0	285.4
Grayish-green, arenaceous shale	..	3.6	283.4
Red arenaceous shale	920.0	3.4	280.4
Concealed to center of a small wash entering stream from south	1000.0	60.0	277.0
Traverse S. 80° E.			
Shale with some thin bands of arenaceous limestone, seen in small wash (thickness approximate)	..	8.0	217.0
Bloomsburg Sandstone Member			
Red sandstone and shale. Partially concealed. Dip 75° W.	1048.0	35.0	209.0
Traverse S. 61° E.			
Red sandstone. Dip 73° W.	..	2.5	174.0
Arenaceous red shale	..	1.0	171.5
Very fissile, arenaceous shale, cross-bedded	..	2.5	170.5
Very fissile red shale, partly concealed	1063.0	6.0	168.0
Red shaly sandstone	1081.0	7.0	162.0
Red shale	..	6.5	155.0
Red sandstone	..	3.0	148.5
Red arenaceous shale	1095.0	5.0	145.5
Red sandstone	..	6.0	140.5
Very arenaceous red shale, almost a sandstone	..	6.0	134.5
Heavy-bedded, arenaceous red shale	1119.0	11.0	128.5
Concealed	..	14.5	117.5
Shaly red sandstone	1143.0	6.0	103.0
Concealed. Red soil	1208.0	45.0	97.0
Red shale	1220.0	3.5	52.0
Red sandstone with some lighter-colored bands. N. 10° E. 34° W. (average of 4 observations of strike and 3 observations of dip.)	1230.0	4.0	48.5
Red shale	1250.0	5.5	44.5
Concealed	1367.0	..	..

Traverse S. 32° E.	Horizontal distance from center of bridge to base of beds Feet	Thickness Beds Feet	Thickness Total Feet
Concealed	1697.0	..	..
The section from 1230 of the horizontal traverse to the base of formation is continued on the steep bank south of the stream. (The red sandstone, seen high upon the hillside, is the same as the bed found at 1230 horizontally.)			
Concealed. Soil gray above, red below	..	39.0	39.0
Total thickness of the Wills Creek formation..			614.3

McKENZIE FORMATION

Grand sandstone	..	4.0	..
Gray shale interbedded with crystalline limestone which abound in *Camarotœchia andrewsi*	..	14.0	..
Creek level. This point is 40 feet above the level of the bridge at beginning of the traverse	1697.0	..	..

CORRELATION OF THE SILURIAN FORMATIONS OF MARYLAND WITH THOSE OF OTHER AREAS

BY

CHARLES K. SWARTZ

The determination of the relation of the geological formations of any region to those of other areas is known as the correlation of the strata. The investigation of this problem constitutes one of the most important questions presented in the study of the geology of any region, involving, as it does, not only the determination of the mutual ages of the deposits and the conditions under which they were accumulated, but also the unravelling of many other aspects of their geological history. Its solution must hence precede and lay the foundation for the comprehension of the geology of the region under investigation.

The Silurian strata of North America can be grouped into a number of geographic provinces which present different lithological and faunal features. Maryland constitutes a part of the Appalachian Province which extends from New York on the north to Alabama on the south and from Maryland on the east to Kentucky and Tennessee on the west. The Silurian strata of North America were first studied critically in this province, especially in New York, so that the beds of that State have become, in large degree, typical for the Silurian formations of North America. It is appropriate, therefore, to consider first the relations of the Silurian of Maryland to that of New York and other parts of the Appalachian Province, and afterwards and more briefly their correlation with those of other provinces.

MEDINAN SERIES

TUSCARORA FORMATION

HISTORICAL REVIEW.—Vanuxem and Hall recognized the existence of a series of arenaceous deposits at the base of the Silurian of New York to which they applied the name Medina sandstone[1] from a small village in western New York. The formation as originally defined consisted of a lower red shale and an upper interbedded sandstone and shale. The lower part was subsequently termed the Queenstown formation by Grabau,[2] while the upper beds were named the Albion by E. M. Kindle.[3] The Albion has been further subdivided into a number of members by Grabau and others. The sequence thus established in New York is as follows: [4]

Medina formation	Albion formation........	Thorold gray sandstone [5]
		Grimsby red and gray sandstone and shale [6]
		Cataract shale [7]
		Whirlpool gray sandstone [8]
	Queenstown red shale	

Both divisions of the Medina thicken southward in passing into Pennsylvania where they were recognized by H. D. Rogers who called the lower the Levant red sandstone and the upper the Levant white sandstone.[9] They were later called the red and white Medina by Lesley [10] and those associated with him in the Second Geological Survey of Pennsylvania.

[1] Vanuxem, Lardner, Geol. Rept. 3d Dist. for 1839, 1840, p. 374; also Geol. New York, pt. iii, 1842, pp. 71-74. Hall, James, Geol. New York, pt. iv, 1843, pp. 34-57.

[2] Grabau, A. W., Science, vol. xxvii, 1908, p. 622. Also called the Lewistown by Chadwick, Geo. H., Science, vol. xxviii, 1908, p. 347.

[3] Kindle, E. M., U. S. Geol. Survey, Folio 190, 1913, p. 6. See explanation of reasons for adoption of this term by Kindle in Science, vol. xxix, 1914, p. 917, footnote.

[4] See excellent discussion of the Medina by E. M. Kindle, Science, vol. xxxix, 1914, pp. 915-918.

[5] Grabau, A. W., Bull. Geol. Soc. Amer., vol. xxiv, 1913, p. 460.

[6] Williams, M. Y., Unpublished paper read before Geol. Soc. Amer. Quoted by Kindle in Science, vol. xxxix, 1914, p. 998.

[7] Schuchert, Charles, Bull. Geol. Soc. Amer., vol. xxiv, 1913, p. 107.

[8] Grabau, A. W., Jour. Geol., vol. xvii, 1909, p. 238.

[9] Rogers, H. D., Geol. Penn., vol. i, 1858, pp. 105, 126-131; vol. ii, 1858, p. 753.

[10] Lesley, J. P., Summary Final Rept., vol. i, 1892, p. 625. See various local reports for usage of associates.

The red Medina of central Pennsylvania was subsequently named the Juniata formation by Darton who called the white Medina the Tuscarora.[1]

The presence of the Medina sandstone in Maryland was early recognized by Rogers who placed it in his Levant sandstone, which he subdivided into three members consisting of upper and lower gray sandstones separated by red shale.[2] In 1860 Tyson called the red shale and overlying sandstone the Medina sandstone, introducing the New York name into Maryland.[3] The red member was subsequently correlated by Clark with Darton's Juniata and the upper white division with his Tuscarora,[4] a usage that has been followed by later writers.

It has been shown by various workers[5] that the Juniata red sandstone interfingers with the marine Richmond beds of Ohio. Ulrich, accepting the base of Hall's Medina as the base of the Silurian, has proposed to include both the Richmond and Queenstown in the Silurian system. The U. S. Geological Survey, however, refers the Juniata to Ordovician as has also been done by the Maryland Geological Survey.[6]

Correlation with Formations of the Appalachian Province and Western New York

Arenaceous formations form the base of the Silurian throughout a large part of the Appalachian area, extending from New York to Virginia and southward. They have received various names in this region but all are closely related.

New York. Relation to Albion Sandstone of Western New York.—The Tuscarora sandstone of Maryland contains three species of fossils, *Arthro-*

[1] Darton, N. H., U. S. Geol. Survey, Folio 28, 1896.
[2] Rogers, H. D., Geol. Penn., 1858, vol. i, p. 105; vol. ii, p. 567.
[3] Tyson, P. T., First Rept. to House of Delegates of Md., 1860, p. 36.
[4] Clark, Wm. B., Md. Geol. Survey, vol. i, 1897, pp. 180-181.
[5] Grabau, A. W., Science, vol. xxii, 1905, pp. 532-533; vol. xxvii, 1908, p. 622; Bull. N. Y. State Mus., No. 92, 1906, pp. 122-123. Chadwick, G. H., Science, vol. xxviii, 1908, p. 347. Ulrich, E. O., Bull. Geol. Soc. Amer., vol. xxii, 1911, pl. 27. Foerste, A. F., Bull. Geol. Soc. Amer., vol. xxiv, 1913, p. 110.
[6] The reader is referred to the Ordovician Monograph of the Md. Geol. Survey for a fuller discussion of its relations. (Cambrian and Ordovician of Maryland, Maryland Geol. Surv., 1919, pp. 170-172.)

phycus alleghaniensis, Scolithus verticalis, and *Camarotœchia neglecta.* The first of these is abundant in the upper part of the Albion of western New York. *Scolithus verticalis* is also found at the top of the Albion, while *Camarotœchia neglecta* is found in the Cataract shale of Ontario which is of Albion age. The Tuscarora of Maryland further resembles the Albion of New York in its arenaceous character and occupies a like stratigraphic position, being underlain by the red Juniata which is of Queenstown age, and overlain by Lower Clinton shales. The close relations of the faunas, lithology and stratigraphic sequence of the Tuscarora of Maryland and Albion of New York indicate that they are of equivalent age.

The Shawangunk sandstone of southeastern New York and northern New Jersey was believed by Mather, who first studied it, to be approximately of Medinan age[1] and by Hall to be of the age of the Oneida sandstone which he placed immediately below the Medina.[2] It was later referred to the Cayugan by Clarke and Hartnagel[3] who based their view, in part upon the discovery of a rich Eurypterid fauna in it. Schuchert,[4] however, has recently reported the abundant occurrence of *Arthrophycus alleghaniensis* in the Shawangunk of southeastern New York indicating the upper Medinan (Albion) age of the beds containing it and has traced their extension into Pennsylvania to unite with the Tuscarora of that State, which is continuous with the Tuscarora of Maryland.[5]

Pennsylvania.—The identity of the Tuscarora of Maryland with the formation of the same name in Pennsylvania is fully established by the fact that the Tuscarora sandstone of Maryland is continuous with that

[1] Mather, W. W., Geol. N. Y., pt. 1, 1843, p. 363.

[2] Hall, James, Geol. N. Y., pt. iv, 1843, p. 31.

[3] Hartnagel, C. A., N. Y. State Mus. Bull. 107, 1907, pp. 50-51; Clarke, J. M., *ibid.*, p. 295 *et. seq.*

[4] Schuchert, C., Bull. Geol. Soc. Amer., vol. xxvi, 1915, p. 150; vol. xxvii, 1916, p. 531.

[5] Contrary to the opinion of other students Ulrich holds that *Arthrophycus alleghaniensis* is not restricted to the Albion but ranges upward into the Upper Clinton in eastern New York. The Tuscarora of Maryland, however, lies below Lower Clinton strata corresponding in this respect to the *Arthrophycus*-bearing strata of the Upper Albion of western New York with which it is here correlated.

of Pennsylvania with which it is also identical in lithology and fossils. Both have also like stratigraphic positions, being underlain by the red Juniata and overlain by the Clinton shales. Their equivalence is evident.

Southern Appalachian States.—The Tuscarora formation may be traced southward into Virginia and Tennessee where beds of similar lithological character have been called the Clinch sandstone.[1] The Clinch sandstone bears *Arthrophycus alleghaniensis* which is the guide fossil of the Tuscarora and occupies a similar stratigraphic position so that it is probable that both represent similar horizons.

Correlation with Formations of Other Provinces

Central States.—Farther west the sandstones are gradually replaced by argillaceous and finally calcareous deposits. With change of habitat the sediments bear a much more abundant fauna which differs so much from that of the Tuscarora as to render detailed correlation of the latter with the sediments of the central United States uncertain.

NIAGARAN SERIES, CLINTON GROUP

ROSE HILL FORMATION

HISTORICAL REVIEW.—The Clinton beds were studied first in central New York by Vanuxem[2] who named them the Protean Group because of their variable character. He subsequently termed them the Clinton formation from their exposure near the village of Clinton in east-central New York.[3] The upper limits of the formation is unfortunately not well shown at the type locality, a fact that has led to much confusion.

James Hall[4] studied similar beds, lying between the Medina and Rochester in western New York and, correlating them with the Clinton of central New York, called them also the Clinton formation. The term as employed by Hall has had a wide usage in the literature.

[1] Safford, J. M., Geol. Tenn., 1869, pp. 292-299.

[2] Vanuxem, Lardner, Geol. Rept. 3d Dist., 1837, 1838, p. 284.

[3] Vanuxem, Lardner, Geol. N. Y., pt. iii, 1842, pp. 79-90.

[4] Hall, James, Geol. Rept. 4th Dist. for 1837, 1838, pp. 297-299; Geol. Rept. N. Y., pt. iv, 1843, pp. 58-79.

Ulrich [1] has recently shown that the upper part of the typical section at Clinton, New York, contains a limited fauna of Rochester facies, including *Dalmanites limulurus,* which he regards diagnostic of that horizon. He hence concludes that the term Clinton should include not only Hall's Clinton but also Hall's Rochester. According to this view, which has also been accepted by the New York Geological Survey,[2] the term Clinton becomes a group name and comprises both Hall's Rochester and the pre-Rochester beds formerly described as Clinton, while Hall's Clinton is left without a name.

Chadwick,[3] who has recently published a critical study of the Clinton of New York arrives at a very different conclusion. He accepts Ulrich's statement as to the range of the faunas in the section at Clinton. He holds, however, that *Dalmanites limulurus,* which Ulrich believes is restricted to the Rochester is not so restricted, but that it ranges downward into the Upper Clinton beneath the Rochester. He believes further that Ulrich has confused the latter beds with the true Rochester which, he states, is absent from the section at Clinton. He would thus employ the term Clinton in Hall's sense.[4]

In view of the facts [5] it has seemed best to apply a new name to the pre-Rochester portion of the section of Maryland. The Maryland pre-Rochester Clinton is hence called the Rose Hill formation in this volume.

[1] Ulrich, E. O., Bull. Geol. Soc. Amer., vol. xxii, 1911, p. 392, pl. xxviii.

[2] Hartnagel, C. A., Classification of the Geologic Formations of the State of New York. Handbook 19, 1912, pp. 49, 50.

[3] Chadwick, G. H., Bull. Geol. Soc. Amer., vol. xxix, 1918, p. 327 *et seq.*

[4] It is to be noted that the disputed beds are equivalent, in a general way, according to Chadwick, to the Irondequoit limestone which bears a fauna of such pronounced Rochester facies that various workers have suggested its inclusion in the overlying Rochester formation.

[5] If Ulrich's interpretation were accepted the term Clinton could still be fittingly restricted, in the opinion of the author, to the beds beneath the strata containing the Rochester fauna, in view of long continued usage of the term in this sense in the literature. The committee on Geological Formational Names of the U. S. Geological Survey has, however, objected to this procedure because of the long-standing commercial use of the name Clinton for iron ores, some of which at least are in the portion of the section assigned to the Rochester by Ulrich.

SUBDIVISIONS OF THE CLINTON OF NEW YORK.—The variable character of the Clinton is clearly indicated by Vanuxem's name, the Protean group, to which reference has already been made. Hartnagel[1] subdivided the Clinton of that state into the following members whose names are derived largely from the western sections:

Top

Irondequoit limestone
Williamson shale
Walcott limestone
Furnaceville iron ore
Sodus shale

Bottom

Chadwick[2] in his study of the Clinton recognized two major divisions in the Clinton of New York, which he called the Upper and Lower Clinton respectively and subdivided as shown in table on p. 190.

Chadwick calls attention to the great difference in the character of the sediments in the western and eastern sections in New York, arenaceous sediments increasing greatly eastward, the changing habitats involving variations in the faunas—a feature that has led to much confusion. He states further that the upper divisions of the Clinton, the Irondequoit limestone and its eastern phases, the Phœnix shale and Herkimer sandstone, contain a fauna of Rochester facies (including *Dalmanites limulurus* in the Phœnix shale); while other Rochester species are found in his Williamson and Brewerton shales.

Ulrich, whose discussion of this problem is given elsewhere in this volume, accepts most of Chadwick's members as valid units but proposes quite a different correlation of various sections of the State. He not only believes that the Rochester is present in the Clinton section but holds that the purple shale of Sodus is not the lithologically similar but faunally different purple shale of Rochester.[3] He states that the true Sodus shale and associated beds, constituting the upper part of his Lower Clinton and the entire Middle Clinton are absent from the Rochester section where

[1] Hartnagel, C. A., Bull. N. Y. State Mus. No. 114, 1907, pp. 12-17.
[2] Chadwick, G. H., Bull. Geol. Soc. Amer., vol. xxix, 1918, p. 356.
[3] The chief faunal difference is in the ostracods.

		Western New York	West-Central New York	East-Central New York
		Rochester Formation	Rochester Formation	Hiatus
CLINTON	Upper	Irondequoit limestone	Lakeport limestone	Herkimer sandstone
			Donally iron ore	
			Phoenix shale	
			Brewerton shale	
		Williamson shale	Williamson shale	VanHornsville sandstone
	Lower		Walcott iron ore	
		Walcott limestone	Walcott limestone	
			Verona iron ore	Oölitic ore
		Sodus shale [1]	Sodus shale	
			Sterling iron ore	
		Reynales limestone	Reynales lime shale	Sauquoit beds
			Furnaceville iron ore	
		Maplewood shale	Martville sandstone	
		Medina		Oneida

[1] It is to be noted that Chadwick's Sodus shale is not the Sodus shale of Hartnagel, the latter worker having confused, in Chadwick's opinion, different units under this name in western and central New York. See discussion in Bull. Geol. Soc. Amer., vol. xxix, 1918, pp. 329, 331.

their position is indicated by an hiatus beneath the Williamson shale, basing his interpretation of the relations of these beds upon the succession of ostracod faunas at Anticosti and elsewhere in the Appalachian basin.[1] His correlation of the section is as follows:

	Western New York	West-Central New York	East-Central New York
Upper	Rochester formation	Rochester formation	Rochester sandstones
	Irondequoit limestone	Schroeppel shale	Shale
		Brewerton shale	
	Williamson shale	Williamson shale	Oölitic ore
Middle	Hiatus	Hiatus	Middle Clinton
Lower		Wolcott limestone	
	Hiatus	Sodus shale	Hiatus
		Sterling ore	
	Bear Creek shale	Hiatus	
	Reynales limestone including Furnaceville shale	Reynales limestone	
	Maplewood shale	Maplewood shale	Oneida conglomerate
	Thorold sandstone	Thorold sandstone	
	Albion	Queenstown	Frankfort

About the time that Hall and Vanuxem were studying the Silurian of New York the Rogers brothers[2] were engaged in the investigation of the corresponding beds in Pennsylvania, Maryland, and Virginia. They clearly recognized the Middle Silurian age of these strata, including them in their Number 5 group, with the strata of that area lying between the

[1] See full discussion elsewhere in this volume.

[2] Rogers, Wm. B., Report of Progress for 1837, Va. Geol. Survey, p. 177, in Rept. of 1884. Rogers, H. D., First Ann. Rept. of State Geologist of Penn., 1836, pp. 5-6.

top of the Medina and the base of the compact limestones of the Tonoloway. H. D. Rogers subsequently limited this division to the beds between the Medina and the top of the Bloomsburg, calling it the Surgent group.[1] Tyson studied the corresponding strata of Maryland a little later and called them the Clinton in 1860.[2] Stevenson subsequently applied the term Clinton to the beds of southern Pennsylvania and Maryland lying between the Medina and a horizon somewhere beneath the Bloomsburg sandstone, the upper limit of this unit being vague.[3] Later Darton and Taff[4] introduced the name Cacapon sandstone for the beds between the top of the Tuscarora and the top of the Cresaptown sandstone and the name Rockwood for the beds lying between the latter and the top of the Bloomsburg sandstone in the vicinity of Piedmont, West Virginia, deriving the formational name from the lithologically similar Rockwood of Tennessee.[5]

In 1897 Clark called the combined Rose Hill and Rochester the Rockwood.[6] In 1900 Prosser, Rowe and O'Harra again named the beds above the Tuscarora the Clinton, including both the Rose Hill and Rochester in the latter term, and correlated them with Hall's Clinton of New York.[7] Schuchert later named the same beds the Lower Niagaran, while he called the McKenzie the Upper Niagaran, believing that the Niagaran beds of Maryland were deposited in a basin distinct from that in which the New York sediments accumulated because of the faunal differences between the forms of life contained in them.[8]

In 1906 Prouty studied the faunas of the Clinton and McKenzie of Maryland. He clearly recognized the Rochester age of the beds above the Keefer sandstone which he combined with the overlying McKenzie to form

[1] Rogers, H. D., Geol. of Penn., 1858, vol. i, pp. 106, 131-134.
[2] Tyson, P. T., First Rept. of State Agri. Chemist of Md., 1860, p. 37.
[3] Stevenson, J. J., 2d Geol. Survey of Penn., vol. T2, 1882, p. 90.
[4] Darton, N. H., and Taff, J. A., U. S. Geol. Survey, Folio 28, 1896.
[5] Hayes, C. W., Bull. Geol. Soc. Amer., vol. ii, 1890, p. 143. The Rockwood of Tennessee is, however, of different age.
[6] Clark, Wm. B., Md. Geol. Survey, vol. i, 1897, pp. 181, 182.
[7] Prosser, C. S., Jour. Geol., vol. ix, 1901, p. 412; O'Harra, C. C., Geol. Allegany County, Md. Geol. Survey, 1900, p. 89.
[8] Schuchert, C., Proc. U. S. Nat. Mus., vol. xxvi, 1903, pp. 415, 424.

his Niagara formation, while he described the beds lying between the Tuscarora and Rochester strata as the Clinton formation.[1]

In 1912 Ulrich, Stose and the writer proposed the name McKenzie formation for the beds between the Rochester and Bloomsburg and included the Rochester formation in the Clinton.[2] Ulrich and Stose, however, placed the Keefer sandstone in the McKenzie in the area embraced in the Pawpaw-Hancock Folio of the U. S. Geological Survey, while they included the Keefer sandstone in the Rochester formation in the vicinity of Cumberland.

FAUNAL RANGE.—Before discussing the larger relations of the Rose Hill it will be helpful to consider the geological and geographic range of the various species contained in it, in so far as this is significant for purposes of correlation. The range of the individual forms is given in the table on distribution, to which the reader is referred.

The following table gives the number of the species in the Rose Hill of Maryland and their range in the Rochester and McKenzie formations of this State:

	Non-ostracods		Ostracods		Total	
	No.	Per cent of Rose Hill species	No.	Per cent of Rose Hill species	No.	Per cent of Rose Hill species
Occurring in the Rose Hill of Maryland:						
Species formerly described.	19	34	1	2	20	36
New species	11	20	25	44	36	64
Total	30	54	26	46	56	100
Occurring in the Rose Hill and Rochester:						
Species formerly described.	13	46	1	4	14	50
New species	5	18	0	0	5	18
Total	18	64	1	4	19	68
Occurring in the Rose Hill and McKenzie:						
Species formerly described.	5	18	0	0	5	18
New species	0	0	0	0	0	0
Total	5	18	0	0	5	18

[1] Prouty, W. F., The Niagara and Clinton Formations of Maryland. Dissertation, Library J. H. Univ., 1906. See also Amer. Jour. Sci., vol. xxv, 1908, pp. 563-576.

[2] Ulrich, E. O., Stose, G. W., Swartz, C. K., U. S. Geol. Survey, Folio 179, p. 5.

The following table exhibits the range of the species formerly described other than ostracods of the Rose Hill of Maryland which have been found in geological formations elsewhere, exclusive of *Atrypa reticularis* and *Leptæna rhomboidalis.* The last have so wide a geologic range that they have little importance for purposes of correlation and hence are not given. Occurrences not significant for correlation are omitted here but are given in detail in the tables showing the distribution to which the reader is referred for further information:

	Number	Per cent of Rose Hill species
Species formerly described occurring in the Rose Hill formation of Maryland	17	100
Occurrence of these species in other areas as follows:		
Pre-Rochester-Clinton of New York	11	65
Rose Hill of other parts of the Appalachian area	10	59
Pre-Rochester-Clinton of western New York	7	41
Pre-Rochester-Clinton of central New York	5	30
Waldron of Indiana and Tennessee	6	35
Racine of Wisconsin	6	35
Rochester of Appalachian area	5	30
Rochester of western New York	5	30
Osgood of Ohio	5	30
Guelph of New York to Wisconsin	5	30
Green River of Anticosti	5	30
Jupiter River of Anticosti	5	30
Europe	3	18

Correlation with Formations of the Appalachian Province and Western New York

Maryland.—An examination of the preceding table shows clearly that the Rose Hill of Maryland is very closely related to the Rochester of this State, nearly two-thirds of the species of the Rose Hill being found in the latter also. While the formations differ it is manifest that they are members of a natural assemblage embraced under the group name Clinton.

New York.—The Rose Hill of Maryland is more closely related to the pre-Rochester Clinton of New York than to any other horizon outside of Maryland. This is shown by the large number of species common to both faunas, 65 per cent of the previously described species of the Rose Hill of Maryland, other than ostracods, occurring also in the pre-Rochester Clinton of New York. The Maryland fauna includes three species, *Cœlospira hemispherica, Tentaculites minutus,* and *Liocalymene clintoni,* which are important guide fossils of this horizon to which they are restricted in New York.

Lithologically the Rose Hill of Maryland closely resembles the pre-Rochester Clinton of central New York, consisting of shales, thin sandstones, limestone and iron ores. Like the latter formation, it becomes increasingly arenaceous toward the east.

The stratigraphic position of the Rose Hill of Maryland is also similar to that of the pre-Rochester Clinton of New York; lying beneath calcareous shales bearing the Rochester fauna and above sandstone of Albion age the latter bearing, in both areas, *Arthrophycus alleghaniensis.* Their relations are exhibited in the following table:

Maryland	New York
Rochester-calcareous shales with *Dalmanites limulurus* fauna	Rochester-calcareous shales with *Dalmanites limulurus* fauna
Rose Hill-argillaceous and sandy beds with *Cœlospira hemispherica* fauna	Pre-Rochester - Clinton-argillaceous and sandy beds with *Cœlospira hemispherica* fauna
Tuscarora-arenaceous beds with *Arthrophycus alleghaniensis*	Albion-arenaceous beds with *Arthrophycus alleghaniensis*

The close relationship of the Rose Hill and the pre-Rochester Clinton of central New York in fauna, lithology, stratigraphic position, and geographic variation pointed out in the foregoing paragraphs, justify their correlation.

Correlation of the Subdivisions of the Rose Hill of Maryland with the New York Section.—Dr. Ulrich has been able to show that the beds beneath the Cresaptown iron sandstone are approximately of the age of the Bear Creek shale of western New York, while the beds immediately overlying that sandstone are later than the Wolcott limestone and hence of Middle Clinton age, basing his reasoning upon the sequence of ostracod faunas at Anticosti and elsewhere in the Appalachian basin.

Pennsylvania.—The Silurian strata of Maryland are clearly traceable across the Maryland-Pennsylvania state line so that they may be correlated by their physical continuity. The early students of the geology of Pennsylvania unfortunately rarely undertook critical studies of the faunas so that correlation must be based chiefly on the lithology of the formations. Rogers, as has been shown in the preceding chapter, early recognized the similarity of the beds above the Tuscarora (white Levant) sandstone of Pennsylvania to the Clinton of New York and named them the Surgent division. He included, in the latter division, the beds between the top of the Medina and the top of the Bloomsburg sandstones and subdivided it into seven lithological divisions[1] as follows: Red marl, upper ore shale, ore sandstone, lower ore shale and fossil ore, upper slate, iron sandstone, lower slate. Rogers' subdivisions are clearly recognizable in the Maryland section, his lower iron sandstone being the Cresaptown sandstone, his fossil ore the Roberts ore, and his red marl the Bloomsburg red beds as shown in the table on page 232. Stevenson later studied the geology of Bedford and Fulton counties, Pennsylvania, immediately adjoining the Maryland-Pennsylvania State line, where he subdivided Rogers' Surgent into the Clinton, Niagara, and Salina formations[2]; his Frankstown iron ore being the same as the Cresaptown iron sandstone and his fossil ore bed the Roberts iron ore as may be shown by tracing these horizons continuously from Pennsylvania into Maryland. His ore sandstone appears to be the Keefer sandstone. The limits set to these units by these workers were, however, often vague and the fossils contained in them were little studied, so that detailed correlation must await further study. The data known permit the correlations shown in the table on page 232.

Southern Appalachian States.—The Clinton strata extend southward in the southern Appalachians with apparently little change in lithology and faunas. They have been described as the Rockwood[3] in that region from their lithological resemblance to the Rockwood of eastern Tennessee

[1] Rogers, H. D., Geol. Survey Penn., vol. i, pt. i, 1858, p. 106.
[2] Stevenson, J. J., 2d Geol. Survey Penn., vol. T2, 1882, pp. 89, 91.
[3] U. S. Geol. Survey, early folios of Southern Appalachians.

although the latter is probably of different age.[1] Butts[2] has more recently described these beds at Birmingham, Alabama, as the Clinton. While their lithology and faunas indicate similarity of age, the correlation of the various units must await further study of the faunas. A considerable contribution to this problem is made by Dr. Ulrich in this volume.

Correlation with Formations of Other Provinces

Central States.—The closest relation of the Rose Hill of Maryland to formations outside the Appalachian basin appears to be with the Crab Orchard formation of central Kentucky. The latter contains *Liocalymene clintoni* and is overlain by the West Union carrying *Dalmanites limulurus,* suggesting its relation to the Rose Hill of Maryland which contains *Liocalymene clintoni* and is overlain by the Rochester bearing *Dalmanites limulurus.*[3] The number of other species common to the two areas is, however, not large and they are chiefly cosmopolitan, suggesting independent basins with some inter-communication in Rose Hill and Rochester time.

Eight species are common to the Rose Hill of Maryland and the Waldron and Racine of the central province and seven to the Rose Hill and the Osgood of the same province. Lesser numbers are found in other formations of the central States but the common forms have a considerable geological range and hence do not indicate close relations.

Acadian Province.—Probably the most significant non-ostracod species of the Rose Hill is *Cœlospira hemispherica,* which has a wide geographic distribution. This species is found in the Gun River, Jupiter River, and Chicotte of the Island of Anticosti and the Ross Brook of Arisaig, Nova Scotia, suggesting approximate equivalence of age.[4] While *Pterinea*

[1] Bassler, R. S., correlates the Rockwood with the Medina (Albion) of New York. See U. S. Nat. Mus. Bull. xcii, vol. ii, 1915, pl. iii.

[2] Butts, Charles, U. S. Geol. Survey, Folio 175, 1910.

[3] This relationship was first pointed out by Foerste.

[4] Chadwick regards the Gun River "Lower Clinton," the Jupiter River "Upper Clinton," and the Chicotte Rochester in age (Bull. Geol. Soc. Amer., vol. xxix, 1918, p. 364). Bassler considers the Gun River to be Albion (U. S. Nat. Mus. Bull. xcii, vol. ii, 1915, pl. iv).

emacerata is also found in the Rose Hill and Gun River. Of interest also is the presence of *Chonetes novascoticus* in the Rose Hill of Maryland and in the McAdam and Moydart of Arisaig.[1] Six other species are common to the two provinces, but their geologic and geographic range is so great that they are not very significant for purposes of correlation.

Ulrich shows elsewhere in this volume by the study of the ostracoda that the beds immediately beneath the Cresaptown iron sandstone are of the age of the upper Gun River formation of Anticosti, while the overlying beds are younger than the Jupiter River which would hence appear to be represented by an hiatus in the Maryland section.

The facts given above indicate that the Maryland and Acadian deposits were probably accumulated in independent basins, which were slightly connected in Rose Hill time.

ROCHESTER FORMATION

HISTORICAL REVIEW.—The Rochester formation was first defined by James Hall[2] who named it from its exposure in the City of Rochester, New York. Hall believed that it lay above the Clinton of Vanuxem. As shown on a preceding page, it has since been included in the Clinton by Ulrich and the New York Geological Survey.

Tyson[3] early embraced the Rochester in the Clinton in Maryland as was also done by Stevenson[4] in southern Pennsylvania and Maryland, although the upper limit of his unit was vague. Darton, Taff[5] and Clark[6] included it in their Rockwood. Prosser[7] and O'Harra[8] again referred it to the Clinton in 1900, while Schuchert[9] made it the upper part of his

[1] The McAdam has been regarded Upper Clinton and the Moydart Lockport by Bassler, *op. cit.*

[2] Hall, James, Geol. Rept., 4th Dist. of N. Y., for 1838, 1839, p. 63.

[3] Tyson, P. T., First Rept. of State Agri. Chemist of Md., 1860, p. 37.

[4] Stevenson, J. J., 2d Geol. Survey Penn., vol. T2, 1882, p. 90.

[5] Darton, N. H., and Taff, Jos., U. S. Geol. Survey, Folio 28, 1896.

[6] Clark, Wm. B., Md. Geol. Survey, vol. i, 1897, p. 181.

[7] Prosser, C. S., Jour. Geol., vol. ix, 1907, p. 412.

[8] O'Harra, C. C., Md. Geol. Survey, Geol. of Allegany Co., 1900, pp. 89-91.

[9] Schuchert, C., Proc. U. S. Nat. Mus., vol. xxvi, 1903, p. 424.

Lower Niagaran in 1903. The Rochester age of the Maryland beds was clearly recognized by Prouty[1] in 1906, and by Ulrich[2] and Stose in 1912.

The Keefer sandstone and overlying beds which have since been shown to contain the *Dalmanites limulurus* fauna were referred to the McKenzie by the latter workers, in the area embraced in the Hancock quadrangle, although they considered the beds above the Keefer sandstone to be of Rochester age in the vicinity of Cumberland. Their true Rochester age in both areas was subsequently shown by Prouty and the writer.[3]

FAUNAL RANGE.—The Rochester formation of Maryland contains 62 species, other than ostracods, of which 29 are new. It also contains 21 species of ostracods, 19 of which are new. The range of these species is shown in the following table:

	Non-ostracods	Ostracods	Total
Total number of species in the Rochester of Maryland..	62	21	83
Occurring in other areas...........................	32	7	39
Occurring in Maryland only.........................	30	14	44
Occurring in the Rose Hill of Maryland...............	18	1	19
Occurring in the McKenzie of Maryland...............	15	0	15

Occurrence of these species in other areas is as follows:

	Non-ostracods	Ostracods	Total
Rochester of western New York......................	20	3	23
Rochester of Pennsylvania...........................	13	6	19
Upper Clinton of Appalachian area....................	9	7	10

Correlation with Formations of the Appalachian Province and Western New York

New York.—The Rochester formation of New York is characterized by abundant *Dalmanites limulurus* which, in the opinion of Ulrich,[4] is re-

[1] Prouty, W. F., The Niagara and Clinton formations of Maryland. MSS. in Library J. H. Univ.; also Amer. Jour. Sci., vol. xxv, 1908, pp. 563-576.

[2] Ulrich, E. O., Stose, G. W., U. S. Geol. Survey, Folio 179.

[3] Prouty, W. F,, and Swartz, C. K., Bull. Geol. Soc. Amer., vol. xxvii, 1916, p. 89.

[4] Ulrich, E. O., U. S. Geol. Survey, Folio 179, 1912, p. 4.

stricted to beds of Rochester age.[1] Chadwick[2] cites this species also from the Phœnix shales which he believes to be below the Rochester, but its abundant occurrence in New York is confined to the Rochester. With it are many other species which are characteristic of the Rochester.

Dalmanites limulurus is also abundant in the Rochester of Maryland where it is associated with *Homalonotus delphinocephalus, Calymene niagarensis, Trematospira camura, Pholidops squamiformis, Rhipidomella hybrida, Spirifer radiatus, Spirifer niagarensis, Tentaculites niagarensis, Conularia niagarensis,* and many other species all of which are well known in the Rochester of New York. Indeed 20 species, or over 60 per cent of the previously described non-ostracod species found in the Maryland beds, occur also in the Rochester of New York and Ontario. The composition of the fauna thus clearly shows its Rochester age.

The number of new species found in the Maryland beds suggests, however, that the latter may have been laid down in a basin which was distinct in some respects from that in which the sediments of New York were accumulated, although connected by sea channel with the latter.

The Maryland strata also closely resemble the Rochester strata of New York in their lithology and their geographic variation, being argillaceous shales interbedded with thin limestones in the west and becoming increasingly arenaceous eastward.

[1] A species of *Dalmanites* referred to *D. limulurus* by Ulrich was found in beds beneath the Keefer sandstone in Maryland. He hence confidently referred these beds to the Rochester formation. It was subsequently shown that these beds are of Rose Hill age and older than the Rochester. Since the discovery of their true position Dr. Ulrich has purposed to discriminate this species as *D. clintonensis.* Its resemblance to *D. limulurus* is, however, so close as readily to permit their union as varieties of a single species.

These results indicate that correlations based upon one or a few forms are open to question. Indeed one cannot forget that species sharply restricted in time at one locality existed presumably earlier elsewhere and hence correlations must be made with reference to these facts. Possibly some of the difficulties in the New York section are due to similar facts.

[2] Chadwick, G. H., Bull. Geol. Soc. Amer., vol. xxix, 1918, pp. 350, 356.

The Rochester strata further occur in like stratigraphic sequence in both areas as shown by the subjoined table.

New York	Maryland
Rochester. Calcareous shale with abundant *Dalmanites limulurus* fauna—beds becoming increasingly arenaceous eastward.	*Rochester.* Calcareous shale with abundant *Dalmanites limulurus* fauna—beds becoming increasingly arenaceous eastward.
Pre-Rochester-Clinton. Argillaceous shale and sandstone with many *Cœlospira hemispherica.*	*Rose Hill.* Argillaceous shale and sandstone with many *Cœlospira hemispherica.*
Albion. Sandstone with *Arthrophycus allegheniensis.*	*Tuscarora.* Massive sandstone with *Arthrophycus allegheniensis.*

Pennsylvania, West Virginia and Southern Appalachians.—But little is known of the Rochester formation in these areas. It is, however, known to pass without essential change in faunas and sequence into parts of West Virginia and Pennsylvania adjacent to Maryland.

Correlation with Formations of Other Provinces

Central States.—An interesting feature of the Rochester fauna of Maryland is the presence in it of a number of species described thus far only from the central provinces of the United States, especially from the south central area. Conspicuous among these forms are *Stropheodonta corrugata* var. *pleuristriata,* described by Foerste from the Clinton of Cumberland Gap, Tennessee, and *Schuchertella tenuis, Uncinulus stricklandi, Spirifer eudora, Meristina maria,* etc., from the Niagaran of that area. We have already commented on the sequence, first noted by Foerste, of *Liocalymene clintoni* in the Crab Orchard of Kentucky and a variety of *Dalmanites limulurus* in the West Union of the same State, similar to the sequence of these species in Maryland. The relations above named suggest a connection of the south central United States with the Maryland Appalachian basin in Middle Silurian time and a migration of Atlantic forms into Tennessee and Kentucky as well as a radiation of species from that area into Maryland. The presence of *Dalmanites limulurus* in the Osgood of Ohio also suggests the inter-communication of these regions.

Acadian Province.—The few known species common to the Rochester of Maryland and the Acadian province are chiefly cosmopolitan forms of wide range and hence have but slight significance for correlation.

Cayugan Series

McKenzie Formation

Historical Review.—The McKenzie shales were not recognized as a distinct formation by early students of the geology of this region. Rogers[1] included them in the "Upper ore shales" of his Surgent group, while Tyson[2] included them in his Clinton. Stevenson[3] placed them in the upper part of his Clinton and the lower part of his Salina and Niagara, with vague limits. They were included in the Lewistown by Darton, Taff[4] and Clark[5] in 1896 and 1897 respectively. Prosser[6] and O'Harra[7] subsequently named them the Niagara formation, while Schuchert[8] called them the Upper Niagaran, stating that they contain a fauna distinct from that of the Upper Niagaran of New York. Prouty[9] investigated them later and combined them with the Rochester in his Niagara formation which he considered to be of Lockport age, although he thought it probable that the Maryland beds were deposited in a separate basin. Ulrich studied them more recently and concluded that they are early Cayugan, basing his opinion upon the faunas, particularly the ostracods.[10]

The McKenzie formation is known only in Maryland and adjacent parts of Pennsylvania and West Virginia, the name being first used in the Paw Paw-Hancock folio of the U. S. Geological Survey.[11]

[1] Rogers, H. D., Geol. Penn., vol. i, pt. 1, 1858, p. 106.
[2] Tyson, P. T., First Rept. State Agri. Chemist, 1860, p. 37.
[3] Stevenson, J. J., 2d Geol. Surv. Penn., vol. T2, 1882, pp. 89, 90.
[4] Darton, N. H., and Taff, Jos. A., U. S. Geol. Survey, Folio 28, 1896.
[5] Clark, Wm. B., Md. Geol. Survey, vol. i, 1897, p. 182.
[6] Prosser, Chas. S., Jour. Geol., vol. ix, 1891, p. 418.
[7] O'Harra, C. C., Md. Geol. Survey, Allegany County, 1890, pp. 91, 92.
[8] Schuchert, Charles, Proc. U. S. Nat. Mus., vol. xxvi, 1903, p. 424.
[9] Prouty, W. F., The Niagara and Clinton of Maryland. MS. in Library of Johns Hopkins University; Amer. Jour. Sci., vol. xxv, 1908, pp. 563-576.
[10] Ulrich, E. O., included the Keefer sandstone in the McKenzie formation in which he was followed by Stose.
[11] Folio 179, U. S. Geol. Surv., 1912.

FAUNAL RANGE.—The McKenzie formation contains 34 species, other than ostracods, of which 23 are new. It also contains 38 species of ostracods, 37 of which are new. The range of the species in other formations is shown in the following table:

	Species other than ostracods	Ostracods	Total
Number of species in the McKenzie of Maryland...	34	38	72
Observed in Maryland only	23	37	60
Occurring in other areas	11	1	12
Occurring in the Rose Hill of Maryland............	5	0	5
Occurring in the Rochester of Maryland...........	15	0	15
Occurring in the Wills Creek of Maryland.........	0	1	1

Range of previously described species (other than *Leptæna rhomboidalis*):

	Species other than ostracods	Ostracods	Total
Occurring in the Rochester of western New York..	5	0	5
Occurring in the Rochester of Appalachian area..	5	0	5
Occurring in the Cobleskill of New York...........	2	0	2

Correlation with Formations of the Appalachian Province and Western New York

Maryland.—The McKenzie formation is but little known outside of Maryland. Whether it is Niagaran or Cayugan can therefore be best investigated by examining its relations to the Niagaran and Cayugan formations of Maryland. The underlying Rochester is undoubtedly Niagaran and the overlying Wills Creek Cayugan. To which of these is the McKenzie most closely related? The question may be examined in the light of the faunal, lithologic, stratigraphic, and diastrophic evidence.

Faunal Evidence.—As stated above the McKenzie formation contains 34 species other than ostracods. Fifteen of these occur in the underlying Rochester formation and one in the Wills Creek. The following seven Rochester species are common in the McKenzie: *Buthotrephis gracilis* var. *intermedia, Dalmanella elegantula, Reticularia bicostata, R. bicostata* var. *marylandica, Whitfieldella marylandica, Tentaculites niagarensis, T. niagarensis* var. *cumberlandiæ.* Eight other Rochester species occur in the McKenzie but are less frequent, *i. e., Orbiculoidea clarki, Stropheodonta corrugata, S. corrugata* var. *pleuristriata, Leptæna* *rhomboidalis, Trematospira camura, Clidophorus nitidus, Diaphorostoma niagarense, Calymene macrocephala.* One other Rochester species, *Calymene niagarensis,* is represented in the McKenzie by a variety *C. niagarensis* var. *restricta.* No non-ostracod species is known to pass from the McKenzie into the Wills Creek while the non-ostracod faunas of these formations are of very different aspect. Thus we have 16 species and varieties of non-ostracods uniting the McKenzie and Rochester, a relationship which would appear to be overwhelmingly Niagaran.

The ostracods, on the contrary, indicate a close relationship between the McKenzie and Wills Creek according to the identifications of Ulrich and Bassler. None of the Rochester ostracods pass into the McKenzie, while one species is common to the McKenzie and Wills Creek. Ulrich states, however, that the ostracods which make up so much of the McKenzie fauna are distinctly Cayugan in type and calls attention to the abrupt change in the ostracod faunas at the top of the Rochester.

It is possible that this divergence in the testimony of the ostracoda and the non-ostracod elements of the faunas is due to the difference in the conditions of accumulation of the formations, the McKenzie containing many well developed marine species, while the Wills Creek forms are chiefly those found in restricted seas so that it is difficult to institute trustworthy comparisons between them. The sharp transition in the character of the ostracods seems to indicate an hiatus between the Rochester and McKenzie although the similarity of the non-ostracod elements does not suggest a long interval.

Lithologic Relations.—The McKenzie strata so closely resemble those of the underlying Rochester formation that it has not proven possible to separate them successfully by their physical features in the field. The McKenzie limestones are on the whole darker and more compact than those of the Rochester but the resemblance is very close. Dr. Ulrich believes that evidence of an unconformity between the Rochester and McKenzie is to be seen in Pennsylvania [1] but its existence is not clear in Maryland. The marine beds of the McKenzie are, however, very distinct from the overlying Wills Creek strata.

[1] Private communication.

Stratigraphic Evidence.—While the faunas do not indicate close relationship between the McKenzie and the overlying fossiliferous horizons the stratigraphic evidence shows conclusively that the marine McKenzie and the Bloomsburg red sandstone are in part at least contemporaneous. Thus the middle and upper beds of the McKenzie intertongue distinctly with the lower part of the red Bloomsburg, their relations being like those of the Catskill and Chemung. It is manifest that the center of deposition of the McKenzie was in the open sea in the west, while that of the Bloomsburg was on the land in the east. Wedges of marine McKenzie are clearly seen to thin eastward and interlock with wedges of red Bloomsburg which in turn thin westward. Thus marine sediments accumulated in the west at the same time that red beds were deposited on the land in the east. Oscillations of sea level caused alternating invasions and recessions of the sea which are witnessed by alternating and interlocking tongues of gray marine and red continental sediments.

The facts recited clearly show that the upper part of the McKenzie is of Cayugan age. Perhaps the great difference between the faunas of the McKenzie and Wills Creek formations may be explained by differences in their habitat rather than by difference of age, the former living in the open sea, while the latter were restricted to what were probably more saline waters (as shown by the salt crystals in the upper part of the Wills Creek formation). The very close affinities of the Rochester and McKenzie non-ostracod faunas raises the question, however, whether the Niagaran and Cayugan series are in reality sharply defined units and whether on the contrary they may not be much more closely related than is usually supposed. This conclusion is also suggested by the close affinity of the Niagaran and Cobleskill of New York which were long thought to be of the same age.[1] The consideration of these facts raises the question how far geological time units may express differences of habitat and physical conditions rather than time relations.

New York.—Five species of the McKenzie, including *Trematospira camura,* a well-defined Niagaran form and *Uncinulus obtusiplicatus,* are

[1] The Cobleskill was first described as Niagaran by James Hall. See Paleontology of New York, vol. ii, 1852, p. 321.

found in the Rochester of western New York. The presence of the latter species is especially suggestive since it has a sharply restricted range in Maryland where it is found in abundance in a well-defined zone situated about 50 feet below the top of the McKenzie. Five species are found in other parts of the Appalachian Rochester, making eight different forms of the McKenzie of Maryland which are also known in Appalachian formations of Rochester age.

Another very interesting occurrence is the presence of the trilobite *Corydocephalus ptyonurus* and the brachiopod *Reticularia bicostata* in the Cobleskill fauna of New York, which, as has already been pointed out, is a recurrent Niagaran assemblage. It thus appears to be evident that, although distinct, there are many Niagaran elements in the McKenzie fauna of Maryland, including also some which are known only in the later recurrent Niagaran (Cobleskill) fauna of Cayugan age.

Correlation with Formations of Other Areas

Central States.—A few species are common to the McKenzie and the Middle Silurian of the central United States but their relations are not significant save perhaps for the occurrence of a form related to *Reticularia bicostata* in the Brownsport of Tennessee of Niagaran age.

Acadian Province.—A few McKenzie species are found also in formations of eastern Canada but none are suggestive save *Uncinulus obtusiplicatus,* which is reported from the McAdam formation of Arisaig, which is perhaps of Rochester age.[1]

The examination of the evidence adduced above seems to show that the McKenzie is closely related to the Niagaran Rochester but is also connected intimately by beds of passage with the overlying Bloomsburg, which appears to the writer to be the Maryland and Pennsylvanian extension of the Vernon red shale of New York of Cayugan age. It is probably separated from the underlying Rochester by an hiatus which does not seem to be large. The great profusion of new species found in it shows that it was laid down in a basin distinct from that in which the marine beds of western New York were deposited.

[1] Bassler, R. S., U. S. Nat. Mus. Bull., xcii, vol. ii, 1915, pl. iv.

WILLS CREEK FORMATION

HISTORICAL REVIEW.—The Bloomsburg red beds were made the upper division of the Surgent by Rogers,[1] who referred the overlying Wills Creek beds to his Scalent, the red and gray beds of the Wills Creek being appropriately called the variegated marls. Tyson[2] accepted Rogers' limits for the Surgent but called the latter the Clinton, while he named the Scalent the Onondaga. Stevenson[3] called the Bloomsburg the Salina and referred the overlying Wills Creek beds to the Lower Helderberg. Darton, Taff,[4] and Clark[5] embraced all the strata between the Keefer and Oriskany sandstones in their Lewistown. O'Harra and Prosser[6] made the Wills Creek Salina and were followed in this by Schuchert.[7] The Wills Creek was discriminated and its present limits assigned by Ulrich, Stose, and the writer in 1912.[8]

FAUNAL RANGE.—The Wills Creek formation contains 11 species other than ostracods, of which seven are new. It also contains 16 species of ostracods, 15 of which are new.

The range of these species is shown in the following table:

	Species other than ostracods	Ostracods	Total
Total number of species	11	16	27
Observed in Maryland only	7	15	22
Found in other areas	4	1	5
Occurring in the Rochester of Maryland	0	1	1
Occurring in the McKenzie of Maryland	0	1	1
Occurring in the Tonoloway of Maryland	9	1	10

Of the previously described species three are known in the Decker Ferry of eastern New York and New Jersey, two in each of the following formations: Cobleskill and Rondout of eastern and central New York, and

[1] Rogers, H. D., Geol. Penn., vol. i, pt. i, 1858, p. 106.
[2] Tyson, P. T., First Rept. St. Agri. Chemist, 1860, p. 37.
[3] Stevenson, J. J., Geol. Penn., vol. T2, 1882, pp. 87, 89.
[4] Darton, N. H., and Taff, Jos., U. S. Geol. Survey, Folio 28, 1896.
[5] Clark, Wm. B., Md. Geol. Survey, vol. i, 1900, p. 182.
[6] O'Harra, C. C., Md. Geol. Survey, Allegany County, 1900, pp. 92, 93. Prosser, C. S., Jour. Geol., vol. ix, 1901, p. 414.
[7] Schuchert, Chas., Proc. U. S. Nat. Mus., vol. xxvi, 1903, p. 415.
[8] U. S. Geol. Survey, Folio 179, 1912.

Wilbur of eastern New York, and one in the Manlius of eastern and central New York.

Correlation with Formations of the Appalachian Province and Western New York

Maryland.—The close faunal relation of the non-ostraeod faunas of the Wills Creek and Tonoloway is shown by the fact that all save two of the Wills Creek species are found in the Tonoloway, though but one of the 16 reported species of ostracods is common to both formations. The non-ostracod species of the Wills Creek and McKenzie are all different, while one species of ostracoda is common to the two formations.

New York.—The fauna of the Wills Creek cannot be compared with those of New York, since most of the lower Cayugan of that State consists of non-marine red strata which are non-fossiliferous, or of barren Salina beds. It is therefore necessary to seek a comparison with the faunas of later Cayugan formations.

The four previously described species of the Wills Creek, *Schuchertella interstriata, Camarotœchia litcheldensis, Spirifer vanuxemi,* and *Calymene camerata* are all found in the Cayugan of New York. *Schuchertella interstriata,* which is the most restricted of these forms, is found in the Cobleskill and Rondout in the central part of that State. *Camarotœchia litchfieldensis* and *Calymene camerata* are of wider range, being found in the Wills Creek, Tonoloway, and Keyser member of the Helderberg of Maryland and in the Wilbur and Cobleskill of New York and Decker Ferry of New Jersey. *Spirifer vanuxemi* appears to be sharply restricted in New York where it has long been considered the guide fossil of the Manlius. In Maryland, however, it ranges from the Wills Creek through the Tonoloway into the Keyser limestone, being an interesting illustration of the manner in which a species having a well-defined time value in one area may have very different limits in another. It is manifest that its advent in the Wills Creek of Maryland is much before its appearance in the Manlius of New York. One ostracod, *Leperditia altoides,* is of Decker Ferry age.

An interesting element of the fauna is the occurrence of Eurypterids and their association with beds containing imprints of salt crystals near the top of the formation in the vicinity of Cumberland.

The faunas above described indicate but little more than that the Wills Creek is of Cayugan age.

Lithology.—There is a close resemblance between the lithology of the lower Cayugan of New York and the Wills Creek of Maryland. The basal beds of the Cayugan of New York consist over a large area of the Vernon red shale which closely resembles the Bloomsburg of Maryland in its lithology and sequence, while the overlying shales carry deposits of salt in New York, suggesting the salt crystals whose imprints are found near the top of the Wills Creek. Indeed the lithological relations are so similar as to suggest their deposition in a single basin.

Stratigraphic Evidence.—In the absence of fossils it may be possible to find very satisfactory evidence of the age of the strata by the study of the climatic, physical, diastrophic, and other conditions attending the deposition of the sediments. Fortunately we have excellent data bearing upon this question in the case of the Wills Creek formation.

Overlying the Pittsford black shale in New York, a thin and local deposit, is a great mass of red non-fossiliferous sediments known as the Vernon red shale and forming, with the Pittsford, the lower part of the Salina of that State. Immediately above the red beds occur the salt beds worked in central New York as a source of commercial salt. These are followed in turn by argillaceous limestones containing gypsum and some salt, known as the Camillus shale. It is manifest that the Cayugan of New York was ushered in by the formation of extensive deposits of salt associated with arid climatic conditions. While we cannot correlate the beds of this period in New York with those of Maryland by fossils, since there are none above the Pittsford in the former State, it is highly probable that salt was deposited in Maryland and New York at essentially the same time, since they are parts of one province. It is, moreover, probable that the conditions which produced aridity would affect the climate of both areas at the same time. As a matter of fact we find imprints of salt crystals in the strata of Maryland, indicating arid conditions here. It is also significant that these salt crystals are underlain by red deposits in Maryland as in New York but with this difference: The red deposits occupy the entire interval between the Pittsford and the salt beds in New York, while they appear only at the base of the Wills Creek in Maryland where the salt crystals appear at the top of the formation. Going eastward in the latter State, we find, however, an increasing development of red beds, until in the North Mountains they occupy a large part of the Wills Creek formation. The deposits east of this point have been removed by erosion. If, however, the same changes continued in them it would not be necessary to go far before the entire Wills Creek formation would be replaced by red beds over which the salt-bearing strata would appear.

The analogy with the New York section is too striking to escape attention. In east central New York continental conditions existed and red beds were deposited in Vernon time followed by increasing aridity and deposition of salt. The open sea lay towards Maryland where marine strata would occupy the same horizon as the red beds of New York. With oscillations of the sea red deposits of the northeast would intertongue with gray marine deposits of the southwest, the percentage of marine deposits increasing towards the open sea. Salt was formed back of the barriers on the shore though less extensively as we approach marine conditions, as we find in Maryland. Moreover, marine fossils appear in increasing numbers towards the southwest, so that more fossils are found in the deposits of Pennsylvania than in those of New York and more in Maryland than in Pennsylvania. Indeed, a change is manifest even in such narrow limits as are presented in the State of Maryland, marine forms appearing in ever increasing numbers towards the southwest, where arenaceous deposits give way first to shale and then to limestone.

It is interesting to find possibilities of correlation based upon climatic and other lines of evidence even in the absence of fossils. Such are manifestly present in this case. We therefore conclude the salt-bearing strata of Maryland and New York are synchronous and that the gray Wills Creek formation of Maryland is the estuarine and marine phase that, together with the McKenzie formation, corresponds to the Vernon shale of New York and the Bloomsburg red beds of Pennsylvania. The relation, in other words, is similar to that of the marine Chemung to the red Catskill of Devonian age. These facts also show that the red Silurian beds, like the Devonian red beds, do not have a definite time value but that they began earlier in the east where they also persisted longer and where their thickness is hence greater.

Pennsylvania.—The above facts also permit correlation of the sediments of Pennsylvania with those of Maryland. Various workers have described the Bloomsburg red beds and the overlying variegated beds in Pennsylvania. These are manifestly strata of the same age as the Bloomsburg and Wills Creek formations of Maryland with which they are continuous and so closely resemble both lithologically and in their stratigraphic relations as to permit little doubt of their identity.

Southern Appalachians.—But little is known of the existence of these beds into the southern Appalachian province. They pass, however, from Maryland into West Virginia without essential change.

General Relations in the Appalachian Province.—The facts presented in the preceding discussion show that we have two well-defined horizons whose positions are known in the northern Appalachian basin, the Rochester with its diagnostic fauna, which can be widely traced, and the salt-bearing strata of the Wills Creek and Salina of New York. Between these lie the McKenzie, Bloomsburg, and major part of the Wills Creek in Maryland, the Bloomsburg and variegated beds in Pennsylvania, and the Vernon red shale in New York. The intertonguing of the gray and red beds of these formations shows that the sea lay towards the south and west and the continent east and north.

Correlation with Formations of Other Provinces

Central States.—Both the Amherstburg and Lucas of northern Ohio and southern Michigan contain *Schuchertella interstriata.* The latter formations were regarded as uppermost Silurian by Grabau [1] but as early Devonian by Stauffer [2] and Bassler.[3]

[1] Grabau, A. W., Mich. Geol. and Biol. Survey, Pub. 2, Geol. Ser. 1, 1909, p. 234.
[2] Stauffer, C. R., Bull. Geol. Soc. Amer., vol. xxvii, 1916, pp. 72-77.
[3] Bassler, R. S., U. S. Nat. Mus. Bull. xcii, vol. i, 1915, pl. iii.

Other Areas.—No satisfactory comparisons can be made between the fauna of the Wills Creek and those of other areas.

TONOLOWAY FORMATION

HISTORICAL REVIEW.—The Tonoloway strata of Maryland were included by Rogers[1] in the Scalent, by Tyson[2] in the Onondaga, and by Stevenson,[3] in adjacent parts of Pennsylvania, in his Lower Helderberg. Later it was assigned to the Lewistown formation with vaguely defined limits by Darton, Taff,[4] and Clark.[5] The lower beds of the Tonoloway were referred to the Salina by Prosser[6] and O'Harra,[7] while the more compact arenaceous strata were placed by them in the Helderberg formation. Schuchert[8] included it in his Salina which embraced in addition the Wills Creek and part of the Keefer. The Tonoloway formation was subsequently discriminated and its present limits assigned to it by Ulrich, Stose, and the writer[9] in 1912.

FAUNAL RANGE.—The Tonoloway formation contains 54 species other than ostracods, 37 of which are new, and 30 species of ostracods,[10] 28 of which are new.

The range of these species is shown in the following table:

	Species other than ostracods	Ostracods	Total
Total number of species	54	30	84
Occurring in Maryland only	39	28	67
Occurring in other areas	15	2	17
Occurring in the Wills Creek of Maryland	9	1	10
Occurring in the Keyser of Maryland	8	0	8
Occurring in the Coeymans of Maryland	3	0	3

[1] Rogers, H. D., Geol. Penn., vol. i, pt. i, 1858, pp. 106-107.
[2] Tyson, P. T., First Rept. State Agri. Chemist, 1860, pp. 37, 38.
[3] Stevenson, J. J., Second Geol. Surv. Pennsylvania, vol. T2, 1882, p. 87.
[4] Darton, N. H., and Taff, Jos., U. S. Geol. Survey, Folio 28, 1896.
[5] Clark, Wm. B., Md. Geol. Survey, vol. i, 1900, p. 182.
[6] Prosser, C. S., Jour. Geol., vol. ix, 1901, pp. 414-415.
[7] O'Harra, C. C., Md. Geol. Survey, Allegany County, 1900, pp. 93, 98.
[8] Schuchert, Chas., Proc. U. S. Nat. Mus., vol. xxvi, 1903, p. 416.
[9] U. S. Geol. Survey, Folio 179, 1912.
[10] Including species reported from Keyser and Grasshopper Run, West Virginia, immediately adjoining the Maryland-West Virginia State line.

The range of the previously described species in other areas is as follows:

	Species other than ostracods	Ostracods	Total
Occurring in the Decker Ferry of New Jersey....	5	0	5
Occurring in the Cobleskill of central New York..	6	0	6
Occurring in the Cobleskill of eastern New York..	5	0	5
Occurring in the Rondout of central New York...	4	0	4
Occurring in the Rondout of eastern New York...	4	0	4
Occurring in the Wilbur of eastern New York....	4	0	4

Correlation with Formations of the Appalachian Province and Western New York

Maryland.—The fauna of the Tonoloway of Maryland is more closely related to that of the Wills Creek than to the fauna of any other horizon, as indicated by the above table, the Keyser of Maryland standing next in the number of common species.

New York.—The uppermost Silurian of New York has been variously interpreted by different workers. Ulrich[1] believes that the Cobleskill, Rondout, and Manlius of central New York are distinct from the formations of the same names in eastern New York, the former being Cayugan and the latter Helderbergian (of Decker Ferry age). Hartnagel,[2] on the contrary, holds that the formations of the same name in that State are of the same age, all being Cayugan, while he contends that the Decker Ferry is of Cobleskill age. It is manifest that the interpretation of the Maryland relations must depend upon the view held as to the New York section.

Ten of the previously described invertebrates of the Tonoloway of Maryland occur in the undoubted Cayugan of central New York, while one additional species is found in the eastern horizons. The range of the species is, however, not such as to permit confident correlations with individual New York formations.

Two Tonoloway species, *Spirifer vanuxemi* and *Tentaculites gyracanthus* (which is represented by a variety in Maryland) are guide fossils of the Manlius of New York but their range is so much greater in Mary-

[1] Ulrich, E. O., cited in volume on Lower Devonian of Maryland, Md. Geol. Survey, 1913, pp. 115-117.

[2] Hartnagel, C. C., New York State Mus., Bull. No. 68, 1903.

land that it does not seem wise to attempt to correlate sharply by them. *Stenochisma lamellata* is found in the Rondout of central New York and also in the Cobleskill and Rondout of eastern New York, which Ulrich regards of Decker Ferry age. One species, *Rhynchospira globosa,* is found in the New Scotland of New York. While the entire assemblage leaves little doubt of its Upper Cayugan age but little more can be deduced from it.

Lithology.—There is a considerable resemblance between the lithology of the Tonoloway and Manlius of New York, both being hard, platy limestones, although the Tonoloway contains beds of purer quality than the Manlius.

Stratigraphic Evidence.—Under these circumstances the stratigraphic evidence affords the best basis of comparison. We have already shown that the upper Wills Creek beds contained salt crystals and are probably of the age of the Syracuse salt beds of New York, while the Keyser limestone is of the age of the Decker Ferry of eastern New York and northern New Jersey.[1] The Tonoloway formation lies between these horizons and would hence appear to represent some part of the interval occupied by the Camillus, Bertie, Cobleskill, Rondout, and Manlius of central New York. The presence of imprints of salt crystals in the lower beds of the Tonoloway would seem to indicate that this part of the section is perhaps of Camillus age, while the upper part represents later formations. Until agreement is reached as to the interpretation of the New York section a closer correlation does not seem possible.

Pennsylvania.—The Tonoloway formation may be followed from Maryland into Pennsylvania where it has received various names. As shown in the preceding discussion, Rogers referred it to his Scalent, Stevenson to his Lower Helderberg, and Darton to his Lewistown which included all the beds from the Rochester limey shales to the Helderberg limestones.

Its relations suggest the Bossardville limestone of eastern Pennsylvania, which closely resembles the Tonoloway in its lithology, and, like it, overlies variegated shales. The Bossardville further resembles the Tonoloway in containing few fossils and these chiefly ostracods. Whether they are

[1] See evidence upon this point in the report on the Lower Devonian of Md., 1913, pp. 110-113.

equivalent can only be determined by a more critical study of the species. The Tonoloway, however, passes without essential change across the state line from Maryland into southern Pennsylvania.

Southern Appalachians.—The Tonoloway extends from Maryland into West Virginia without change. Its relations farther south are unknown.

Correlation with Formation of Other Areas

Central States.—The most abundant species, other than ostracods, in the Tonoloway of Maryland is *Hindella congregata,* which is especially profuse in the lower and middle part of the formation. This species is represented by a related form, *Hindella congregata,* in the Cayugan Greenfield of Ohio. Other members of the two faunas are, however, so distinct as to forbid correlation.[1]

General Conclusions.—The relations may be summed up by the statement that the Tonoloway may be traced continuously from Maryland into West Virginia on the south and Pennsylvania on the north. It may be compared in a general way with the beds above the Syracuse salt beds of New York and below the Decker Ferry of New Jersey and eastern New York, but in the absence of faunas no precise equivalent can be assigned at present. It may perhaps be more closely compared with the Bossardville limestone of central and eastern Pennsylvania and New Jersey, but the faunas of the latter are chiefly ostracods and are not well known. At present the Tonoloway stands apart as a Maryland formation whose relations to the beds of other areas must be determined by later study. The evidence adduced shows, however, that it is of Cayugan age. A summary of correlations proposed is shown on page 232.

DISTRIBUTION OF THE FAUNA

The following tables show the geological and geographical distribution of the fossils that have been collected in the deposits of the Silurian system in the State of Maryland and in the contiguous areas. The first table is devoted to organisms other than ostracoda and the second table is devoted to the ostracoda. The species recorded in these tables are described in the systematic part of this work.

[1] See A. W. Grabau's discussion of the relations of these areas in Mich. Geol. and Biol. Survey, Publication 2, Series 1, 1909, pp. 225-234.

SPECIES	APPALACHIAN AREA																								
	MARYLAND								NEW YORK TO ALABAMA																
	Albion	Clinton			Cayugan			Helderberg	Albion		Clinton		Cayugan						Cayugan or Helderburg					Helderberg	
	Tuscarora	Rose Hill	Keefer	Rochester	McKenzie	Wills Creek	Tonoloway	Keyser	Shawangunk	Tuscarora	Pre-Rochester	Rochester	Salina, central N. Y.	Cobleskill, central N. Y.	Rondout, central N. Y.	Manlius, central N. Y.	New Bloomfield, Pa.	Bossardville, Pa.	Wilbur, S. E. N. Y.	Cobleskill, S. E. N. Y.	Decker Ferry, N. J.	Rondout, S.E. N.Y. & N.J.	Manlius, S.E. N.Y. & N.J.	Keyser, Pa.	Coeymans, N. Y.-Md.
PLANTÆ																									
Buthotrephis gracilis var. *intermedia* Hall		*		*	*						*														
CŒLENTERATA. Anthozoa																									
Favosites niagarensis Hall					*		*																		
Favosites marylandicus Prouty n. sp					*																				
Favosites sp				*																					
Aulopora tonolowayensis Swartz n. sp							*																		
COELENTERATA. Hydrozoa																									
Stromatopora constellata Hall							*	*						*						*					*
VERMES																									
Cornulites concavus Prouty n. sp				*																					
Cornulites rosehillensis Prouty n. sp		*		*																					
Cornulites cancellatus Prouty n. sp				*																					
Scolithus verticalis Hall	*																								
Scolithus keeferi Prouty n. sp			*																						
Arthrophycus alleghaniensis (Harlan)	*								*	*															
MOLLUSCOIDEA. Brachiopoda																									
Lingula clarki Prouty n. sp					*																				
Lingula subtruncata Prouty n. sp					*																				
Lingula n. sp. Prouty n. sp					*																				
Lingula sp						*																			
Orbiculoidea clarki Prouty				*	*																				
Orbiculoidea sp							*																		
Pholidops squamiformis (Hall)				*																					
Pholidops sp					*																				
Dalmanella elegantula (Dalman)		*	*		*						*	*													
Rhipidomella hybrida (Sowerby)		?	*	*	?																				
Leptæna rhomboidalis (Wilckens)		*	*	*	*			*				*		*					*	*	*				*
Stropheodonta corrugata (Conrad)		*	*	*	*							*													
Stropheodonta corrugata var. *pleuristriata* (Foerste)		*		*	*						*														
Stropheodonta convexa Prouty n. sp		*	*																						
Stropheodonta deflecta Prouty n. sp				*																					
Stropheodonta acuminata Prouty n. sp				*																					
Stropheodonta varistriata (Conrad)							*	*								*							*		*
Stropheodonta (*Leptostrophia*) *bipartita* var. *nearpassi* Barrett							*	*						?					?	?	*	?			
Stropheodonta sp							*																		
Schuchertella subplana (Conrad)				*																					
Schuchertella tenuis Hall		*		*																					
Schuchertella elegans Prouty n. sp				*																					
Schuchertella interstriata (Hall)						*	*							*	*										
Schuchertella rugosa Swartz n. sp							*																		
Schuchertella sp																									
Chonetes novascoticus Hall		*																							
Chonetes sp																									
Conchidium cumberlandicum Prouty n. sp		*																							
Gypidula ? sp						*																			
Stenochisma ? lamellata (Hall)							*	*						*	*				*	*	*	*			
Uncinulus marylandicus Swartz n. sp						*	*																		
Uncinulus obsolescens Swartz n. sp						*	*																		
Uncinulus cf. *stricklandi* (Sowerby)			*	*																					
Uncinulus obtusiplicatus (Hall)					*																				
Camaratœchia andrewsi Prouty n. sp					*																				
Camaratœchia ? neglecta Hall	*	*	*	*							*														
Camaratœchia litchfieldensis (Schuchert)						*	*	*											*	*	*	*			
Camaratœchia litchfieldensis var. *marylandica* Swartz n. sp							*																		
Camaratœchia tonolowayensis Swartz n. sp						*	*																		

SOUTH CENTRAL AREA											NORTH CENTRAL AREA																						ACADIAN AREA												
ALBION		CLINTON				LOCKPORT					ALBION		CLINTON						LOCKPORT							CAYUGAN				MONROE			ALBION	CLINTON						LOCKPORT	CAYUGAN		DEVONIAN		
Edgewood, Ill. to Mo.	Brassfield, Ohio to Okla.	Dayton, Ohio	Crab Orchard, Ky.	Osgood, Ohio	West Union, Ky.	Laurel, Ind. to Tenn.	Waldron, Ind. to Tenn.	Brownsport, Tenn.	Louisville, Ind. to Ky.	Niagaran, Ill. Iowa, Mo.	Cataract, Ont.	Albion, N. Y.	Sodus, N. Y.	Wolcott, N. Y.	Williamson, N. Y.	Irondequoit, N. Y.	Rochester, N. Y.	Rochester, Ontario	Lockport, N. Y.	Waukesha, Wis.	Racine	Niagara, North Ind.	Springfield, Ohio	Cedarville, Ohio	Guelph, Wis. to N. Y.	Kokomo, Ind.	Greenfield, Ohio	Bertie, N. Y.	Akron, N. Y.	Raisin River, Mich.	Amherstburg, Mich.	Lucas, Ohio-Mich. Ontario	Becsie River, Anticosti	Gun River, Anticosti	Jupiter River, Anticosti	Chicotte, Anticosti	Beech Hill Cove, Arisaig	Ross Brook, Arisaig	McAdam, Arisaig	Moydart, Arisaig	Stonehouse, Arisaig	Pembroke, Me.	Dalhousie, New Brunswick	Gaspe, Quebec	Europe
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SPECIES	APPALACHIAN AREA																								
	MARYLAND								NEW YORK TO ALABAMA																
	Albion	Clinton			Cayugan			Helderberg	Albion		Clinton		Cayugan						Cayugan or Helderberg					Helderberg	
	Tuscarora	Rose Hill	Keefer	Rochester	McKenzie	Wills Creek	Tonoloway	Keyser	Shawangunk	Tuscarora	Pre-Rochester	Rochester	Salina, central N. Y.	Cobleskill, central N. Y.	Rondout, central N. Y.	Manlius, central N. Y.	New Bloomfield, Pa.	Bossardville, Pa.	Wilbur, S. E. N. Y.	Cobleskill, S. E. N. Y.	Decker Ferry, N. J.	Rondout, S.E. N.Y. & N.J.	Manlius, S.E. N.Y. & N.J.	Keyser, Pa.	Coeymans, N. Y.,-Md
Atrypa reticularis Linnaeus		*	*	*				*			*	*		*					*	*	*				*
Spirifer mckenzicus Prouty n. sp					*																				
Spirifer (Delthyris) crispus (Hisinger)				*								*													
Spirifer (Delthyris) vanuxemi (Hall)						*	*	*							*	*					?	*	*		
Spirifer (Delthyris) vanuxemi var. *tonolowayensis* Swartz n. var							*								?	?					?	?	?		
Spirifer (Delthyris) keyserensis Swartz n. sp							*																		
Spirifer (Delthyris) corallinensis Grabau							*							*	*										
Spirifer (Eospirifer) radiatus (Sowerby)		*		*						*	*														
Spirifer (Eospirifer) eudora Hall		*	*																						
Spirifer (Eospirifer) niagarensis (Conrad)			*																						
Spirifer sp																									
Reticularia bicostata (Vanuxem)				*	*									*							*				
Reticularia bicostata var. *marylandica* Prouty n. var				*	*									?							?				
Rhynchospira globosa (Hall)							*	*																	*
Homœospira evax var. *marylandica* Prouty n. var					*																				
Trematospira camura Hall				*	*																				
Hindella ? (Greenfieldia) congregata Swartz n. sp						?	*																		
Hindella ? (Greenfieldia) congregata var. *intermedia* Swartz n. var							*																		
Hindella ? (Greenfieldia) congregata var. *pusilla* Swartz n. var							*																		
Hindella ? (Greenfieldia) rotundata (Whitfield)							*																		
Meristina cf. *maria* Hall				*																					
Meristina globosa Prouty n. sp		*		*																					
Meristina sp					*																				
Whitfieldella marylandica Prouty n. sp				*	*																				
Whitfieldella subovata Prouty n. sp				*																					
Cœlospira hemispherica (Sowerby)		*									*														
Cœlospira sulcata Prouty n. sp		*	*																						
MOLLUSCA. Pelecypoda																									
Cuneamya ulrichi Prouty n. sp					*																				
Grammysia kirklandi Prouty n. sp		*																							
Ctenodonta subcircularis Prouty n. sp				*																					
Ctenodonta subreniformis Prouty n. sp					*																				
Ctenodonta ovata Prouty n. sp				*																					
Ctenodonta willsi Prouty n. sp		*																							
Clidophorus nitidus Prouty n. sp				*	*																				
Clidophorus suboblongatus Prouty n. sp		*																							
Clidophorus sp					*																				
Pterinea emacerata (Conrad)		*	*	*							*	*									*				
Pterinea flintstonensis Prouty n. sp					*																				
Pterinea elongata Prouty n. sp				*																					
Pterinea cancellata Prouty n. sp				*																					
Actinopteria ? sp						*																			
Liopteria subplana Hall				*				*						*											
Liopteria pennsylvanica Swartz n. sp							*																		
Liopteria sp					*																				
Modiolopsis gregarius Swartz n. sp							*																		
Modiolopsis cumberlandicus Prouty n. sp				*																					
Modiolopsis subcarinatus Hall		*										*													
Modiolopsis leightoni Williams ?							*																		
Orthonota ? marylandica Swartz							*																		
MOLLUSCA. Gastropoda																									
Bucanella trilobita (Conrad)		*		*							*														
Oxydiscus compressus Prouty n. sp				*																					
Bellerophon marylandicum Prouty n. sp				*																					
Hormatoma rowei Swartz n. sp						*	*																		
Hormatoma rowei var. *nana* Swartz n. var							*																		

South Central Area											North Central Area																						Acadian Area												
Albion		Clinton				Lockport					Albion		Clinton						Lockport							Cayugan				Monroe			Albion	Clinton						Lockport	Cayugan		Devonian		
Edgewood, Ill. to Mo.	Brassfield, Ohio to Okla.	Dayton, Ohio	Crab Orchard, Ky.	Osgood, Ohio	West Union, Ky.	Laurel, Ind. to Tenn.	Waldron, Ind. to Tenn.	Brownsport, Tenn.	Louisville, Ind. to Ky.	Niagaran, Ill., Iowa, Mo.	Cataract, Ont.	Albion, N.Y.	Sodus, N.Y.	Wolcott, N.Y.	Williamson, N.Y.	Irondequoit, N.Y.	Rochester, N.Y.	Rochester, Ontario	Lockport, N.Y.	Waukesha, Wis.	Racine	Niagara, North Ind.	Springfield, Ohio	Cedarville, Ohio	Guelph, Wis. to N.Y.	Kokomo, Ind.	Greenfield, Ohio	Bertie, N.Y.	Akron, N.Y.	Bass River, Mich.	Amherstburg, Mich.	Lucas, Ohio, Mich. Ontario	Becsie River, Anticosti	Gun River, Anticosti	Jupiter River, Anticosti	Chicotte, Anticosti	Beech Hill Cove, Arisaig	Ross Brook, Arisaig	McAdam, Arisaig	Moydart, Arisaig	Stonehouse, Arisaig	Pembroke, Me.	Dalhousie, New Brunswick	Gaspe, Quebec	Europe
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SPECIES	APPALACHIAN AREA																								
	MARYLAND								NEW YORK TO ALABAMA																
	Albion	Clinton			Cayugan			Helderberg	Albion		Clinton		Cayugan						Cayugan or Helderburg					Helderberg	
	Tuscarora	Rose Hill	Keefer	Rochester	McKenzie	Wills Creek	Tonoloway	Keyser	Shawangunk	Tuscarora	Pre-Rochester	Rochester	Salina, central N. Y.	Cobleskill, central N. Y.	Rondout, central N. Y.	Manlius, central N. Y.	New Bloomfield, Pa.	Bossardville, Pa.	Wilbur, S. E. N. Y.	Cobleskill, S. E. N. Y.	Decker Ferry, N. J.	Rondout, S.E. N.Y. & N.J.	Manlius, S.E. N.Y. & N.J.	Keyser, Pa.	Coeymans, N. Y., Md.
Hormatoma marylandica Prouty n. sp.					*																				
Hormatoma hopkinsi Prouty n. sp.					*																				
Hormatoma sp.																									
Solenospira minuta Hall							*									*									
Holopea ? flintstonensis Prouty n. sp.							*																		
Poleumita transversa Prouty n. sp.				*																					
Poleumita mckenzica Prouty n. sp.					*																				
Loxonema sp.							*																		
Orthonychia clarki Prouty n. sp.				*																					
Platyceras paucispirale Prouty n. sp.				*																					
Platyceras niagarense (Hall)			*	*																					
Diaphorostoma niagarense Hall				*	*						?	*													
Styliola sp.				*																					
Coleolus interstriatus Prouty n. sp.				*																					
Tentaculites minutus Hall		*									*														
Tentaculites niagarensis Hall				*	*																				
Tentaculites niagarensis var. *cumberlandiæ* Hall				*	*																				
Tentaculites gyracanthus var. *marylandicus* Swartz n. var.							*	*								?							?		
Tentaculites sp.																									
Conularia niagarensis Hall				*																					
MOLLUSCA. Cephalopoda																									
Orthoceras bassleri Prouty n. sp.		*																							
Orthoceras mckenzicum Prouty n. sp.					*																				
Orthoceras sp.							*																		
Cycloceras clintoni Prouty n. sp.				*																					
Sphyradoceras cf. *desplainense* (McChesney)		*		*																					
Trochoceras ? marylandicum Swartz n. sp.							*																		
Oncoceras mckenzicum Prouty n. sp.					*																				
Tetrameroceras cumberlandicum Swartz n. sp.							*																		
Tetrameroceras cumberlandicum var. *magnacameratum* Swartz n. var.							*																		
ARTHROPODA. Trilobita																									
Proetus sp.							*																		
Corydocephalus ptyonurus (Hall)					*									*											
Encrinurus ornatus Hall and Whitfield				*							*														
Liocalymene clintoni (Vanuxem)		*	*								*														
Calymene niagarensis Hall		*	*	*								*		*											
Calymene niagarensis var. *restricta* Prouty n. sp.					*																				
Calymene macrocephala Prouty n. sp.		*		*	*																				
Calymene cresapensis Prouty n. sp.		*																							
Calymene camerata (Conrad)						*	*	*						*					*	*	*				
Calymene sp.																									
Homalonotus delphinocephalus (Green)		?	*	*								*													
Homalonotus lobatus Prouty n. sp.				*																					
Dalmanites limulurus (Green)		*	*	*								*													
Dalmanites limulurus var.		*																							
ARTHROPODA. Eurypterida																									
Eurypteris flintstonensis Swartz n. sp.							*																		
Hughmilleria sp. cf. *Shawangunk* Clarke and Ruedemann						*			*																
Dolichopterus cumberlandicus Swartz n. sp.						*																			
Dolichopterus ? sp.				*																					
Pterygotus ? sp.				*																					
VERTEBRATA. Pisces																									
Palæaspis americana Claypole							*										*								

SOUTH CENTRAL AREA											NORTH CENTRAL AREA																						ACADIAN AREA												
ALBION		CLINTON				LOCKPORT					ALBION		CLINTON						LOCKPORT							CAYUGAN				MONROE			ALBION	CLINTON						LOCKPORT	CAYUGAN		DEVONIAN		
Edgewood, Ill. to Mo.	Brassfield, Ohio to Okla.	Dayton, Ohio	Crab Orchard, Ky.	Osgood, Ohio	West Union, Ky.	Laurel, Ind. to Tenn.	Waldron, Ind. to Tenn.	Brownsport, Tenn.	Louisville, Ind. to Ky.	Niagaran, Ill., Iowa, Mo.	Cataract, Ont.	Albion, N. Y.	Sodus, N. Y.	Wolcott, N. Y.	Williamson, N. Y.	Irondequoit, N. Y.	Rochester, N. Y.	Rochester, Ontario	Lockport, N. Y.	Waukesha, Wis.	Racine	Niagara, North Ind.	Springfield, Ohio	Cedarville, Ohio	Guelph, Wis. to N. Y.	Kokomo, Ind.	Greenfield, Ohio	Bertie, N. Y.	Akron, N. Y.	Bass River, Mich.	Amherstburg, Mich.	Lucas, Ohio-Mich., Ontario	Becsie River, Anticosti	Gun River, Anticosti	Jupiter River, Anticosti	Chicotte, Anticosti	Beech Hill Cove, Arisaig	Ross Brook, Arisaig	McAdam, Arisaig	Moydart, Arisaig	Stonehouse, Arisaig	Pembroke, Me.	Dalhousie, New Brunswick	Gaspe, Quebec	Europe
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	CLINTON																													
	UPPER																MIDDLE								LOWER						
	Sir John's Run (Devil's Nose), Md.	Six-Mile House, Md.	Wills Creek, Cumberland, Md.	Flintstone, Md.	State Line, e. of Richard Mountain, Md.	1 mi. w. Stone Cabin Gap, Md.	Lakemont, Pa.	2 mi. w. Hollidaysburg, Pa.	Juniata County, Pa.	Hollidaysburg, Pa.	2 mi. e. Great Cacapon, W. Va.	1½ mi. e. Great Cacapon, W. Va.	Big Stone Gap, Va.	Gap, 1½ mi. nw. Warm Springs, Va.	Mulberry Gap, Powell Mt., Tenn.	Lockport, N. Y.	Cumberland, Md.	Near toll-gate, Cove Gap, near Mercersburg, Pa.	1 mi. nw. Frankstown, Pa.	Gate City, Va.	Gap, 1½ mi. nw. Warm Springs, Va.	Near Hartford, N. Y.	New Hartford, N. Y.	Armuchee, Ga.	Wills Mountain, Cumberland	Wills Creek, Cumberland	Cumberland	1½ mi. sw. Cherrytown, Pa.	½ mi. nw. Frankstown, Pa.	¾ mi. s. Reedsville, Pa.	Cove Gap, Tuscarora Mt., Pa.
Leperditia elongata Weller var. *willsensis* n. var.																															
Leperditia mathewsi n. sp.																															
Leperditia altoides Weller var. *marylandica* n. var.																															
Leperditia scalaris præcedens n. var																															
Leperditia alta cacaponensis n. var.											*																				
Leperditia alta brevicula n. var.																															
Leperditia scalaris præcedens n. var																															
Leperditia alta (Conrad) Jones																															
Aparchites ? obliquatus n. sp.																															
Aparchites ? punctillosa n. sp.																															
Aparchites ? variolatus n. sp.																										*					
Aparchites alleghaniensis n. sp.																															
Eridoconcha rotunda n. sp.																															
Primitiella equilateralis n. sp.																															
Euprimitia buttsi n. sp.																												*			
Laccoprimitia resseri n. sp.																															
Chilobolbina billingsi (Jones)																															
Chilobolbina hartfordensis n. sp.																							*								
Chilobolbina punctata n. sp.																															
Chilobolbina punctata brevis n. sp.																	*														
Apatobolbina ? appressa n. sp.																													*		
Apatobolbina granifera n. sp.								*																							
Paræchmina spinosa (Hall)																															
Paræchmina crassa n. sp.																															
Paræchmina abnormis Ulrich																*															
Paræchmina postica n. sp.																															
Paræchmina intermedia n. sp.																															
Paræchmina altimuralis n. sp.																															
Paræchmina depressa n. sp.																															
Paræchmina postmuralis n. sp.																		*													
Paræchmina bimuralis																															
Paræchmina inæqualis n. sp.																															
Paræchmina simplex n. sp.																															
Paræchmina cumberlandica n. sp.																															
Paræchmina punctata n. sp.																															
Paræchmina ? dubia n. sp.																															
Bollia pulchella n. sp.																															
Bollia immersa n. sp.																															
Bollia nitida n. sp.																															
Halliella fissurella n. sp.																															
Halliella subequata n. sp.																															
Halliella ? triplicata Ulrich and Bassler																															
Zygobolba erecta n. sp.																												*			
Zygobolba carinifera n. sp.																												*			
Zygobolba reversa n. sp.																															

CLINTON							LAKEMONT																McKENZIE									WILLS CREEK					TONOLOWAY										
Lower							Upper								Lower								Upper			Middle		Lower				Upper		Middle		Lower	Top	Base									
8 mi. s. Big Stone Gap, Va.	Gate City Gap, Va.	New River, 1 mi. w. of Narrows, Va.	Narrows, Va.	Cumberland Gap, Tenn.	New Hartford, N. Y.	Mulberry Gap, Powell Mt., Tenn.	½ mi. e. Great Cacapon, Md.	Cumberland, Md.	Rose Hill, Md.	Pinto, Md.	Lakemont, Pa.	McKees, 7 mi. w. Lewiston, Pa.	Hollidaysburg, Pa.	Lakemont, Pa.	Cumberland, Md.	Six-Mile House, Md.	Lakemont, Pa.	Hollidaysburg, Pa.	2 mi. w. Hollidaysburg, Pa.	Great Cacapon, W. Va.	2 mi. e. Great Cacapon, W. Va.	Williamsville, Va.	Flintstone, Md.	Pinto, Md.	Cumberland, Md.	Cumberland, Md.	Pinto, Md.	Flintstone, Md.	Cumberland, Md.	1½ mi. e. Great Cacapon, Md.	1½ mi. e. Great Cacapon, W. Va.	Cumberland, Md.	Grasshopper Run, near Hancock	Cedar Bluff, Md.	Flintstone	Pinto	Keyser, W. Va.	Grasshopper Run, W. Va.	Grasshopper Run, near Hancock	Cumberland	Pinto, Md.	Keyser, W. Va.	Top of Dyer Bay dolomite, Clay Cliffs, 2 mi. w. of Cabot Head, Lake Huron, Ont.	Jupiter River formation, Island of Anticosti	Manlius limestone, Schoharie, N. Y.	Mt. Wissick, Temiscouta Lake, Quebec	Manlius, Herkimer Co., N. Y.
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	Sir John s Run (Devil s Nose). Md.	Six-Mile House. Md.	Wills Creek, Cumberland, Md.	Flintstone, Md.	State Line, e. of Richard Mountain, Md.	1 mi. w. Stone Cabin Gap, Md.	Lakemont, Pa.	2 mi. w. Hollidaysburg, Pa.	Juniata County, Pa.	Hollidaysburg, Pa.	2 mi. e. Great Cacapon, W. Va.	1½ mi. e. Great Cacapon, W. Va.	Big Stone Gap, Va.	Gap, 1½ mi. nw. Warm Springs, Va.	Mulberry Gap, Powell Mt., Tenn.	Lockport. N. Y.	Cumberland, Md.	Near toll-gate, Cove Gap, near Mercersburg, Pa.	1 mi. nw. Frankstown, Pa.	Gate City, Va.	Gap, 1½ mi. nw. Warm Springs, Va.	Near Hartford, N. Y.	New Hartford, N. Y.	Armuchee, Ga.	Wills Mountain, Cumberland	Wills Creek. Cumberland	Cumberland	1¼ mi. sw. Cherrytown, Pa.	½ mi. nw. Frankstown, Pa.	¾ mi. s. Reedsville, Pa.	Cove Gap, Tuscarora Mt., Pa.
Zygobolba arcta n. sp																															
Zygobolba venusta (Billings)																															
Zygobolba bimuralis n. sp																											*				
Zygobolba decora (Billings)																															
Zygobolba elongata n. sp																												*			
Zygobolba williamsi n. sp																															
Zygobalba minima n. sp																											*				
Zygobolba limbata n. sp																												*			
Zygobolba obsoleta n. sp																													*		
Zygobolba buttsi n. sp																													*		
Zygobolba pulchella n. sp																													*		
Zygobolba parifinita n. sp																												*			
Zygobolba rustica n. sp																													*		
Zygobolba anticostiensis n. sp																									*						
Zygobolba excavata n. sp																									*						
Zygobolba oblonga n. sp																									*						
Zygobolbina conradi n. sp																	?	?	?	*			*	*							
Zygobolbina conradi latimarginata n. var																											*			*	
Zygobolbina panda n. sp																			*												
Zygobolbina carinata n. sp																			*												
Zygobolbina emaciata n. sp																		*													
Zygosella vallata n. sp																															
Zygosella vallata nodifera n. var		*													*																
Zygosella alta n. sp													*		*																
Zygosella macra n. sp																															
Zygosella cristata n. sp																															
Zygosella postica n. sp																											*				
Zygosella gracilis n. sp																															*
Zygosella brevis n. sp																															*
Zygosella mimica n. sp																					*										
Zygosella limula n. sp																															*
Mastigobolbina virginia n. sp			*									*		*																	
Mastigobolbina typus n. sp		*					*			*	*																				
Mastigobolbina typus var		*																													
Mastigobolbina triplicata (Foerste)																															
Mastigobolbina arguta n. sp																															
Mastigobolbina rotunda n. sp																															
Mastigobolbina intermedia n. sp																															
Mastigobolbina trilobata n. sp																															
Mastigobalbina arctilimbata n. sp																															
Mastigobolbina glabra n. sp																															
Mastigobolbina punctata n. sp																															
Mastigobolbina lata (Hall) Ulrich and Bassler																						*					*				
Mastigobolbina lata var. *nana* n. var																		*				*									
Mastigobolbina clarkei n. sp																						*									

CLINTON							LAKEMONT																McKENZIE									WILLS CREEK					TONOLOWAY										
Lower							Upper								Lower								Upper			Middle		Lower				Upper		Middle		Lower	Top	Base									
8 mi. s. Big Stone Gap, Va.	Gate City Gap, Va.	New River, 1 mi. w. of Narrows, Va.	Narrows, Va.	Cumberland Gap, Tenn.	New Hartford, N. Y.	Mulberry Gap, Powell Mt., Tenn.	½ mi. e. Great Cacapon, Md.	Cumberland, Md.	Rose Hill, Md.	Pinto, Md.	Lakemont, Pa.	McKees, 7 mi. w. Lewiston, Pa.	Hollidaysburg, Pa.	Lakemont, Pa.	Cumberland, Md.	Six-Mile House, Md.	Lakemont, Pa.	Hollidaysburg, Pa.	2 mi. w. Hollidaysburg, Pa.	Great Cacapon, W. Va.	2 mi. e. Great Cacapon, W. Va.	Williamsville Va.	Flintstone, Md.	Pinto, Md.	Cumberland, Md.	Cumberland, Md.	Pinto, Md.	Flintstone, Md.	Cumberland, Md.	1½ mi. e. Great Cacapon, Md.	1½ mi. e. Great Cacapon, W. Va.	Cumberland, Md.	Grasshopper Run, near Hancock	Cedar Bluff, Md.	Flintstone	Pinto	Keyser, W. Va.	Grasshopper Run, W. Va.	Grasshopper Run, near Hancock	Cumberland	Pinto, Md.	Keyser, W. Va.	Top of Dyer Bay dolomite, Clay Cliffs, 2 mi. w. of Cabot Head, Lake Huron, Ont.	Jupiter River formation, Island of Anticosti	Manlius limestone, Schoharie, N. Y.	Mt. Wissick, Temiscouta Lake, Quebec	Manlius, Herkimer Co., N. Y.
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	CLINTON																														
	UPPER																MIDDLE								LOWER						
	Sir John's Run (Devil's Nose), Md.	Six-Mile House, Md.	Wills Creek, Cumberland, Md.	Flintstone, Md.	State Line, e. of Richard Mountain, Md.	1 mi. w. Stone Cabin Gap, Md.	Lakemont, Pa.	2 mi. w. Hollidaysburg, Pa.	Juniata County, Pa.	Hollidaysburg, Pa.	2 mi. e. Great Cacapon, W. Va.	1½ mi. e. Great Cacapon, W. Va.	Big Stone Gap, Va.	Gap, 1½ mi. nw. Warm Springs, Va.	Mulberry Gap, Powell Mt., Tenn.	Lockport, N. Y.	Cumberland, Md.	Near toll-gate, Cove Gap, near Mercersburg, Pa.	1 mi. nw. Frankstown, Pa.	Gate City, Va.	Gap, 1½ mi. nw. Warm Springs, Va.	Near Hartford, N. Y.	New Hartford, N. Y.	Armuchee, Ga.	Wills Mountain, Cumberland	Wills Creek, Cumberland	Cumberland	1½ mi. sw. Cherrytown, Pa.	½ mi. nw. Frankstown, Pa.	¾ mi. s. Reedsville, Pa.	Cove Gap, Tuscarora Mt., Pa.
Mastigobolbina ultima n. sp.		*																													
Mastigobolbina micula n. sp.		*																													
Mastigobolbina vanuxemi n. sp.																											*				
Mastigobolbina declivis n. sp.																															*
Mastigobolbina modesta n. sp.																															
Mastigobolbina bifida n. sp.																															
Mastigobolbina retifera n. sp.																													*		
Mastigobolbina incipiens n. sp.																													*		
Mastigobolbina producta n. sp.																													*		
Bonnemaia celsa n. sp.				*							*																				
Bonnemaia crassa n. sp.										*																					
Bonnemaia obliqua n. sp.			*		*										*																
Bonnemaia perlonga n. sp.						*																									
Bonnemaia rudis n. sp.																															
Bonnemaia fissa n. sp.																															
Bonnemaia longa n. sp.	*		*												*																
Bonnemaia pulchella n. sp.			*																												
Bonnemaia notha n. sp.																															
Bonnemaia transita n. sp.																															
Bonnemaia oblonga n. sp.	*									*																					
Plethobolbina typicalis n. sp.											*																				
Plethobolbina ornata n. sp.																															
Plethobolbina cornigera n. sp.																															
Plethobolbina sulcata n. sp.																		*													
Plethobolbina cribraria n. sp.																											*				
Zygobeyrichia ventripunctata n. sp.																															
Zygobeyrichia regina n. sp.																															
Zygobeyrichia tonolowayensis n. sp.																															
Zygobeyrichia incipiens n. sp.																															
Zygobeyrichia ventricornis n. sp.																															
Zygobeyrichia ventricornis obsoleta n. var.																															
Zygobeyrichia modesta n. sp.																															
Welleria obliqua n. sp.																															
Welleria obliqua longula n. var.																															
Welleria obliqua brevis n. var.																															
Kyammodes swartzi n. sp.																															
Kyammodes tricornis n. sp.																															
Drepanellina clarki n. sp.																															
Drepanellina modesta n. sp.																															
Drepanellina ? simplex n. sp.																															
Drepanellina confluens n. sp.																															
Drepanellina ventralis n. sp.																															
Drepanellina claypalei n. sp.									*																						
Euklœdenella indivisa n. sp.																															
Euklœdenella umbonata m.																															

CLINTON							LAKEMONT																McKENZIE									WILLS CREEK					TONOLOWAY										
Lower							Upper								Lower								Upper			Middle		Lower				Upper		Middle		Lower	Top	Base									
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	Sir John's Run (Devil's Nose), Md.	Six-Mile House, Md.	Wills Creek, Cumberland, Md.	Flintstone, Md.	State Line, e. of Richard Mountain, Md.	1 mi. w. Stone Cabin Gap, Md.	Lakemont, Pa.	2 mi. w. Hollidaysburg, Pa.	Juniata County, Pa.	Hollidaysburg, Pa.	2 mi. e. Great Cacapon, W. Va.	1½ mi. e. Great Cacapon, W. Va.	Big Stone Gap, Va.	Gap 1½ mi. nw. Warm Springs, Va.	Mulberry Gap, Powell Mt., Tenn.	Lockport, N. Y.	Cumberland, Md.	Near toll-gate, Cove Gap, near Mercersburg, Pa.	1 mi. nw. Frankstown, Pa.	Gate City, Va.	Gap 1½ mi. nw. Warm Springs, Va.	Near Hartford, N. Y.	New Hartford, N. Y.	Armuchee, Ga.	Wills Mountain, Cumberland	Wills Creek, Cumberland	Cumberland	1½ mi. sw. Cherrytown, Pa.	½ mi. nw. Frankstown, Pa.	¾ mi. s. Reedsville, Pa.	Cove Gap, Tuscarora Mt., Pa.
Euklœdenella umbilicata n. sp.																															
Euklœdenella umbilicata curta n. var.																															
Euklœdenella primitoides n. sp.																															
Euklœdenella primitoides minor n. var.																															
Euklœdenella brevis n. sp.																															
Euklœdenella simplex n. sp.																															
Euklœdenella sinuata n. sp.																															
Euklœdenella sinuata angulata n. var.																															
Euklœdenella sinuata proclivis n. var.																															
Euklœdenella dorsata n. sp.																															
Euklœdenella punctillosa n. sp.																															
Euklœdenella sulcifrons n. sp.																															
Euklœdenella abrupta n. sp.																															
Euklœdenella longula n. sp.																															
Euklœdenella similis n. sp.																															
Euklœdenella foveolata n. sp.																															
Euklœdenella bulbosa n. sp.																															
Klœdenella obliqua n. sp.																															
Klœdenella rectangularis n. sp.																															
Klœdenella cacaponensis n. sp.																															
Klœdenella scapha n. sp.																															
Klœdenella scapha brevicula n. var.																															
Klœdenella subovata n. sp.																															
Klœdenella nitida n. sp.																															
Klœdenella immersa																															
Klœdenella gibberosa n. sp.																															
Klœdenella transitans n. sp.																															
Dizygopleura proutyi n. sp.																															
Dizygopleura pricei n. sp.																															
Dizygopleura lacunosa n. sp.																															
Dizygopleura minima n. sp																															
Dizygopleura gibba n. sp.																															
Dizygopleura carinata n. sp.																															
Dizygopleura acuminata n. sp.																															
Dizygopleura acuminata prolapsa n. var.																															
Dizygopleura affinis n. sp.																															
Dizygopleura bulbifrons n. sp.																															
Dizygopleura intermedia n. sp.																															
Dizygopleura intermedia antecedens n. var.																															
Dizygopleura intermedia cornuta n. var.																															
Dizygopleura planata n. sp.																															
Dizygopleura subdivisa n. sp.																															
Dizygopleura micula n. sp.																															
Dizygopleura asymmetrica n. sp.																															
Dizygopleura cranei n. sp.																															

CLINTON							LAKEMONT																McKENZIE									WILLS CREEK					TONOLOWAY										
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8 mi. s. Big Stone Gap, Va.	Gate City Gap, Va.	New River, 1 mi. w. of Narrows, Va.	Narrows, Va.	Cumberland Gap, Tenn.	New Hartford, N. Y.	Mulberry Gap, Powell Mt., Tenn.	½ mi. e. Great Cacapon, Md.	Cumberland, Md.	Rose Hill, Md.	Pinto, Md.	Lakemont, Pa.	McKees, 7 mi. w. Lewiston, Pa.	Hollidaysburg, Pa.	Lakemont, Pa.	Cumberland, Md.	Six-Mile House, Md.	Lakemont, Pa.	Hollidaysburg, Pa.	2 mi. w. Hollidaysburg, Pa.	Great Cacapon, W. Va.	2 mi. e. Great Cacapon, W. Va.	Williamsville, Va.	Flintstone, Md.	Pinto, Md.	Cumberland, Md.	Cumberland, Md.	Pinto, Md.	Flintstone, Md.	Cumberland, Md.	1½ mi. e. Great Cacapon, Md.	1½ mi. e. Great Cacapon, W. Va.	Cumberland, Md.	Grasshopper Run, near Hancock	Cedar Bluff, Md.	Flintstone	Pinto	Keyser, W. Va.	Grasshopper Run, W. Va.	Grasshopper Run, near Hancock	Cumberland	Pinto, Md.	Keyser, W. Va.	Top of Dyer Bay dolomite, Clay Cliffs, 2 mi. w. of Cabot Head, Lake Huron, Ont.	Jupiter River formation, Island of Anticosti	Manlius limestone, Schoharie, N. Y.	Mt. Wissick, Temiscouta Lake, Quebec	Manlius, Herkimer Co., N. Y.
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Dizygopleura loculata n. sp.																															
Dizygopleura concentrica n. sp.																															
Dizygopleura concentrica subquadrata n. var.																															
Dizygopleura swartzii n. sp.																															
Dizygopleura pinguis n. sp.																															
Dizygopleura falcifera n. sp.																															
Dizygopleura symmetrica n. sp.																															
Dizygopleura stosei n. sp.																															
Dizygopleura macra n. sp.																															
Dizygopleura halli (Jones)																															
Dizygopleura halli obscura n. var.																															
Dizygopleura subovalis n. sp.																															
Dizygopleura simulans n. sp.																															
Dizygopleura simulans limbata n. var.																															
Dizygopleura clarkei (Jones)																															
Dizygopleura virginica n. sp.																															
Dizygopleura costata n. sp.																															
Dizygopleura perrugosa n. sp.																															
Dizygopleura unipunctata n. sp.																															
Klœdenia normalis n. sp.																															
Klœdenia normalis appressa n. var.																															
Klœdenia kenziensis n. sp.																															
Klœdenia cacaponensis n. sp.																															
Klœdenia obscura n. sp.																															
Klœdenia longula n. sp.																			*												
Octonaria cranei n. sp.																															
Octonaria muricata n. sp.																															
Bythocypris phaseolus Jones																															
Bythocypris phillipsiana Jones and Hall																															
Bythocypris obesa Jones																															
Bythocypris phaseolina n. sp.																															
Bythocypris ? keyserensis n. sp.																															
Bythocypris pergracilis n. sp.																															
Beyrichia emaciata n. sp.																															
Beyrichia kirki n. sp.																									*						
Beyrichia lakemontensis n. sp.																															
Beyrichia mesleri n. sp.																															
Beyrichia tonolowayensis n. sp.																															
Beyrichia veronica n. sp.																															
Beyrichia moodeyi n. sp.																															
Dibolbina cristata n. sp.																															
Dibolbina producta n. sp.																															

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Rogers Bros. Pennsylvania, 1836 Virginia, 1837		Rogers, H. D. Pennsylvania, 1858	Tyson, P. T. Maryland, 1860		Stevenson, J. J. Pennsylvania 1882	Darton and Taff, Piedmont, W. Va., 1896	Clark, Wm. B. Maryland, 1897	Prosser and O'Harra, Maryland, 1900	Schuchert, C. Maryland, 1903	Prouty, W. F. Maryland, 1906		Ulrich and Stose, Maryland, 1912			Swartz, Maryland, 1922
No. 6	Premeridian	Limestone		Lower Helderberg	c. Limestone, massive	Lewistown	Lewistown	Helderberg	Helderberg	Helderberg	Helderberg	Keyser	Helderberg		Keyser
									Manlius	Manlius					
	Scalent	Limestone Gray marls Variegated marls	14b=Onondaga						Salina	Salina		Tonoloway	Tonoloway		Upper limestone
					b. Limestone, flaggy										Shale
															Middle limestone
No. 5					a. Shale and thin limestone			Salina							Indian Spring sandstone
															Shale
															Lower limestone
												Wills Creek	Wills Creek		Upper shale—salt
															Upper sandstone zone
															Middle shale
															Lower sandstone zone
															Lower shale
	Surgent	Red marl	14a=Clinton		Salina and Niagara		Rockwood					Bloomsburg member of Wills Creek			Bloomsburg red sandstone and Cedar Cliff limestone
		Upper ore shale						Niagara	Upper Niagaran	Niagara		McKenzie	McKenzie		Upper shale and limestone
															Rabble Run red beds
				Clinton	Shale			Clinton	Lower Niagaran						Lower shale and limestone
						Rockwood							Clinton	Rochester	Shale and limestone
					Fossil ore and sandstone					Clinton					Roberts iron ore
		Ore sandstone													Keefer sandstone
		Fossil ore Upper shale			Shale							Clinton		Rose Hill	Upper shale
		Iron sandstone					Cacapon sandstone								Cresaptown iron sandstone
		Lower slate			Shale and black ore										Lower shale and sandstone
No. 4	Levant	White sandstone	13=Medina	Medina	White Medina	Tuscarora	Tuscarora	Tuscarora	Tuscarora	Tuscarora		Tuscarora			Tuscarora
		Red sandstone			Red Medina	Juniata	Juniata	Juniata	Juniata	Juniata		Juniata			Juniata
		Grey sandstone													

AMERICAN SILURIAN FORMATIONS[1]

BY

E. O. ULRICH AND R. S. BASSLER

INTRODUCTORY STATEMENTS

OLD AND NEWER CLASSIFICATIONS

Various methods of grouping the Silurian formations of America have been proposed since 1840 and up to 1910. Regarding them all we may say at once that none of them were based on a line of reasoning that covered all the facts known even at their respective dates. In the early days the data were relatively few and the efforts of the systematic stratigrapher, when measured by modern standards, correspondingly unbalanced and unsatisfactory. However, they met the then apparent needs of the science very well and the foothold quickly attained by them was maintained for many years. But the very great increase in detailed knowledge—especially since we began to realize that the continental seas were not as we had believed, long-enduring, broad, and deep, but shallow, often small, and frequently shifting—has finally driven us to the admission that what was sufficient for the simple needs of our predecessors in the science is no longer a satisfactory means for classifying the mass of exceedingly complicated data now available.

The time-honored classification of the Paleozoic rocks in America first introduced by the pioneer New York geologists, Vanuxem, Emmons, Mather, and especially James Hall, in the fifth decade of the last century, stood almost untouched for 50 years. In its essential features their classification was adopted by James D. Dana in 1863 and maintained with such minor modifications as the progress of knowledge necessitated

[1] Published by permission of the Director of the U. S. Geological Survey and the Secretary of the Smithsonian Institution.

in the four editions of his excellent Manual of Geology. However, we are concerned here with only the "Upper Silurian" part of his classification; and this sustained no essential change in the four decades through which it prevailed. In the first edition of the Manual the term Silurian is used with the Murchisonian significance in which it included all the Paleozoic rocks beneath the Devonian. In succeeding editions only the last, published in 1896, shows any decided change from the first arrangement. In 1896, the two major divisions of the Silurian are not only recognized as distinct systems, but the dividing line between them is also the boundary between the Eopaleozoic and Neopaleozoic into which Dana divided the Paleozoic. Moreover, the "Lower Silurian" is greatly restricted by the separation of its lower part as a distinct "Cambrian" system. But as we have said, the "Upper Silurian" is nearly or practically the same as in the first edition. In both it was divided into three "periods," the Niagara, Salina, and Lower Helderberg; but we see a difference in the subdivisions of the "Niagara period." In the first it includes four "epochs" named from below upward, Oneida, Medina, Clinton, and Niagara, in the last only three epochs, the Oneida of the older arrangement being united with the revised Medina of the new classification. The term Niagara, it will be observed, is used in two widely different senses, first for the period and then again for a subordinate part. But this is in accord with the practice commonly followed by Dana of giving the name of the most widely distributed or otherwise best characterized stratigraphic unit to the group or "period" to which it is assigned.

The confusion and embarrassment that naturally arose from this practice is cited as the most important of the reasons that induced Clarke and Schuchert[1] to propose an amended "Nomenclature of the New York Series of Geological Formations." Above all other divisions of the New York Series the Silurian system sustained the greatest change. First, all but the lowest member or formation (the "Tentaculite" or Manlius limestone) of the old Lower Helderberg "period" is removed to the base of the Devonian. Next, the Manlius, together with a new formation, the

[1] Clarke, J. M., and Schuchert, Charles, Science, Dec. 15, 1899; Am. Geologist, Feb., 1900.

Rondout, is joined with the Salina to make the "Cayugan group (Neontaric)." Finally, the "Niagara period" of Dana is divided into two groups, "Niagaran (Mesontaric)" and "Oswegan (Paleontaric)," and the old terms Rochester shale and Lockport limestone are revived and substituted for "Niagara shale" and "Niagara limestone." The Niagaran in this classification begins with the Clinton and ends with the Guelph, thus having four divisions. The Oswegan contains only two stages, the Oneida conglomerate (including the Shawangunk grit) at the base and the Medina sandstone above.

In 1903 Clarke[1] issued another classification of the rocks of the state of New York, with additional explanatory notes. The Silurian in this handbook differs from the preceding Clarke and Schuchert arrangement chiefly in that a new formation, the Cobleskill limestone, is intercalated in the Cayugan between the Salina and the Rondout. Geographic names are also introduced or adopted for the five members or beds of the Salina (Pittsford shale, Vernon shale, Syracuse salt, Camillus shale, and Bertie waterlime, the last at the top).

Geologists generally recognized that these two efforts to improve the classification of the Silurian rocks in America were distinctly progressive in their modifications of the preceding Hall-Dana classification. But always there are conservatives in every department of human endeavor who would hold to most, or at least to certain parts, of old standards; and usually it is those parts on which their personal energies have not been fully engaged. In a way science is greatly benefited by their reactionary efforts. Discussion of the points at issue keeps our interest alive and adds to the vigor of our science. Better still, opposition forces the exponents of the newer views to gather and present more and more evidence and thus finally to prove every step of the way.

It is, therefore, not strange that before long objections to various parts of the Clarke and Schuchert classification were offered. However, no change of consequence appeared until 1908[2] when Chadwick submitted a "rearrangement of a part of Clarke and Schuchert's classification of

[1] Clarke, J. M., Classification of the New York series of geologic formations: New York State Mus., Handbook 19, 1903.

[2] Chadwick, George H., Science, N. S., vol. xxviii, Sept. 11, 1908, p. 346.

the New York Paleozoic, including changes based chiefly upon the recent work of Hartnagel and others." Chadwick would have us return to the broader Niagaran of Dana, with this difference, that the Lewiston (which is the same as Grabau's Queenston) is removed from the Medina to the Cincinnatian leaving the upper Medina, to which he restricts this name and under which he includes the Oneida, to form the basal part of the Niagaran. On the other hand, Chadwick divides the Cayugan of Clarke and Schuchert into two equal parts, retaining the name Cayugan for the upper three formations (Cobleskill, Rondout, and Manlius) and using Salinan for the five Salina beds. The Niagaran represents the "Eontaric," the Salinan the "Mesontaric," and the restricted Cayugan the "Neontaric." The Shawangunk, High Falls, Binnewater, Wilbur, and Rosendale beds of the Silurian in eastern New York are referred to the Salinan and placed so as to appear as correlatives respectively of the Pittsford, Vernon, Syracuse, Camillus, and Bertie beds of the Salina in western New York. Chadwick's proposal, as will be seen, is in part reactionary and in part ultraprogressive.

The Silurian in Grabau's 1909 classifications[1] is essentially as in Chadwick's classification. But the two tables published by Grabau in 1909 differ, aside from the fact that the first includes formations in the Appalachian and Mississippi valleys that are not covered in the second, in that the Queenston, which he correlates with the Juniata and Bays, is placed in the Lorraine age in Science, whereas its greater part is correlated with the Richmond in the Journal of Geology. In both of Grabau's papers we see a "Lower Siluric or Niagaran," a "Middle Siluric or Salinan," and an "Upper Siluric or Monroan." His Niagaran differs from Chadwick's Niagaran in that the Clinton is made to include the "Medina sandstone (sens-strict.), including the Oneida conglomerate. Tuscarora sandstone, and Clinch sandstone." Beneath the Clinton and at the base of the Niagaran he places the "Cape Girardeau or Alexandrian (a possible equivalent of some of the Clinton divisions given above)." Another difference is seen in the second paper where he uses the term

[1] Grabau, A. W., Science, N. S., vol. xxix, Feb. 26, 1909, p. 356; Jour. Geology, vol. xvii, May, 1909, table p. 252.

Niagara in the two senses in which it was formerly employed by Dana. Finally, it appears from his recognition in east-central New York of Oneida conglomerate, followed by "Clinton (of type section)" and this by "Niagara," that he proposes to confine the Clinton here to beds older than the Rochester. As the Irondequoit limestone is not mentioned we cannot say whether its horizon is to be included in his "Clinton" or his "Niagara."

In 1910 Schuchert[1] published a classification of the Silurian in various parts of America that differs from all others preceding it. Compared with Clarke and Schuchert's 1889 arrangement and that of Clarke in 1903 the main differences are found in the grouping of the formations beneath the Salina. There is a lower and a middle series corresponding loosely with the Oswegan and Niagaran of the former classification, but the boundary between the two is not the same. Thus, whereas the Niagaran formerly included the whole of the Clinton its base is now drawn between the Irondequoit and the Williamson divisions of the Clinton in western New York. The Clinton itself is restricted to the beds beneath the Irondequoit, that is, to the Sodus shale, Wolcott limestone, and Williamson shale, and referred, with the older "Ohio Clinton" and the Upper Medina, to the basal Silurian series to which the names Anticostian or Alexandrian are applied. Schuchert's present conception of the Silurian differs further from the prevailing official classification of the New York Survey, which he had helped to frame, in that it follows Chadwick and Grabau in restricting the Medina to the, in New York, relatively thin "Upper Medina" or Albion group, as it has been called since by Clarke, and in referring the main lower mass, for which Grabau in the meantime had proposed the name Queenston, to the Eopaleozoic.

Schuchert on this occasion also expands the time value of the post-Rochester part of the Niagaran by inserting the Upper and Lower Coral beds and the Racine limestone of the Wisconsin section between the Lockport and Guelph formations of the New York section. The Cayugan, however, has the same value originally given it by Clarke and Schuchert,

[1] Schuchert, Charles, Paleogeography of North America: Bull. Geol. Soc. America, vol. xx, 1910, p. 533.

but we note a concession to the views of Chadwick and Grabau in the recognition of their Salinan and Monroan series as groups under Cayugan.

In the following year Ulrich[1] published correlation tables of Paleozoic formations in southeastern North America. The Silurian is represented in greater detail than heretofore and with several important innovations. As in all of the recent classifications the Silurian system is divided into three series, the Medinan[2] beneath, the Niagaran in the middle, and the Cayugan above. Group divisions are not indicated under the Medinan, but the Niagaran is divided into two groups, the Clinton below and the Chicago above. The Cayugan also is divided into a Lower Cayugan and an Upper Cayugan group. In the time scale eight units are recognized under the Medinan. Of these the Noix and the Girardeau of Missouri, with which the Oneida and a part of the upper Medina (see p. 267) are correlated, are placed at the top, while the Dubuque of Iowa is at the base; and the divisions of the Richmond in Indiana occupy most of the intermediate spaces. In the Niagara series the Clinton group includes, in ascending order, the Brassfield, Sodus, St. Clair, Williamson, and Rochester. The sequence of the Chicago group comprises eight units with the Laurel of Indiana at the base and the Louisville of Kentucky at the top. For present purposes it is unnecessary to speak further of the Cayugan than to say that, in accord with then prevailing practice, the Shawangunk is referred to the Salina. The most important innovation in this classification is the definite correlation of the Queenston and Richmond and the inclusion of the latter with the Upper Medina to make the lowest of the three Silurian series. The reference of the Brassfield to the base of the Clinton was a mistaken concession to the views of Foerste, Chadwick, and Grabau.

The next classification to appear is found in the 1912 edition of Handbook 19, prepared for the New York State Museum by C. A. Hartnagel. The classification of the Silurian formations in New York as given now differs in at least three important respects from that given in the first

[1] Ulrich, E. O., Revision of the Paleozoic systems: Bull. Geol. Soc. America, vol. xxii, pl. 28, 1911.

[2] By an inadvertence the names of the lower series and of its two groups were omitted from the charts.

edition. Namely, (1) the Rochester shale is now included in the Clinton; (2) the distinctness of the Oneida conglomerate and the Oswego sandstone is recognized, the latter taking the place formerly given to the Oneida at the base of the Silurian system while the Oneida is viewed as corresponding to a part of the Upper Medina; and (3) the term Richmond, which is placed beneath the Oswegan in the first edition, is now dropped from the New York column without comment. Another difference concerns the Shawangunk conglomerate which is subordinated to the Oneida in the first edition but is now placed at the base of the Salina.

In 1914 Ulrich[1] published another classified correlation chart that differs in important particulars from his 1911 classification. The Brassfield is dropped into the Medina where it belongs, the Medinan is divided into two groups, and the Cataract of Schuchert is correlated with the Upper Medina of New York for which the term Albion is adopted. Schuchert accepted these changes in his 1914 paper on the Cataract formation[2] except that he follows Chadwick and Grabau in restricting the Medina to the sandstones above the Queenston and in drawing the Ordovician-Silurian boundary between these two parts of the original Medina. Other changes affecting this series are (1) the introduction of the Edgewood and Whiteoak formations in the Upper Medinan part of the time scale. (2) the substitution of the term Elkhorn for Saluda at the top of the Richmond or Lower Medinan part, and (3) the climination of the term Dubuque at its base. In the Niagaran part the Clinton group is divided and constituted essentially as before except for the already mentioned transfer of the Brassfield to the Medinan; and for the upper group the term Lockport is used instead of Chicago.

In 1915 Bassler published a classification of the formations mentioned in his Bibliographic Index of Ordovician and Silurian Fossils. The sequence, correlation, and classification of the Silurian formations as given in his charts are in all essential respects as in Ulrich's classification of the preceding year.

[1] Ulrich, E. O., The Ordovician-Silurian boundary: Report 12th Session Intern. Geol. Congr., pp. 593-667, 1914.

[2] Schuchert, Charles, Medina and Cataract formations of the Siluric of New York and Ontario: Bull. Geol. Soc. Am., vol. xxv, pp. 277-320, 1914.

The latest attempt to revise the classification of American Silurian formations is by Chadwick,[1] who on this occasion confines his discussion to the formations of the lower half of the system. As on previous occasions he terminates the Silurian below at the base of the Whirlpool sandstone, the Queenston being referred to the Richmond series and this to the Ordovician. The "Eontaric or Anticostian" comprises all the beds between the top of the Queenston and the base of the Lockport dolomite, and this he divides at the base of the Williamson shale into an Upper Eontaric and Lower Eontaric. Each of these subdivisions is then divided into three or four mostly unnamed major formations which he provisionally designates by the letters A, B, C, and D, and which he correlates respectively with the Becsie River, Gun River, Jupiter River, and Chicotte formations of the Island of Anticosti. Numerous new members of these formations are distinguished and named, some of them having become necessary through the proof that the previously instituted terms Sodus shale, Wolcott limestone, and Williamson shale had been wrongly applied to lithologically similar but otherwise quite distinct members. These corrections are regarded as the most valuable parts of this work on Silurian formations of New York.

GENERAL COMMENTS ON METHODS OF CLASSIFYING SEDIMENTARY ROCKS

In our opinion each of these taxonomic schemes contains some one or more features that make it to a corresponding extent an improvement on its predecessors; and doubtless others will be presented after this that will be similarly distinguished. Therefore no claim to permanency can be made for the best we can offer now. Indeed, it is doubtful if an altogether satisfactory arrangement is possible. Geologic history is too complicated to lend itself readily to systematic classification under prevailing conditions. The main difficulty lies in the discoordinateness of the units of the several grades, especially the "formations"; and purely personal factors add continually to our embarrassment. One goes in for extreme detail and he names every bed that can be distinguished by

[1] Chadwick, George H., Stratigraphy of the New York Clinton: Bull. Geol. Soc. Am., vol. xxix, pp. 327-368, 1918.

peculiarities in character of rock and fauna. Another is not so conscientious; and he may give a new formation name to a mass that would better be referred to under the name of the group, series, or system which it represents. And the nomenclatural product of both is governed by the same rule. Often the systematic stratigrapher might help himself easily enough except for some rule of nomenclature which forbids his desire to modify the original definition of the incongruous unit. Rigid rules have their bad as well as good qualities. Fortunately our rules permit us some latitude in the redefinition and application of group, series, and systemic terms though even in these cases we are bound rather more than is necessary by precedent and the exact form of the original definition.

But the most prolific source of disagreement and ensuing embarrassment lies in the prevailing disregard of uniformity in taxonomic methods. One geologist bases his judgment regarding the position of a given bed in the time scale solely on the general aspect of the fauna of the bed in question; another considers the introduction of new faunal types, or the mere presence of one or more supposedly characteristic species, as surer, or at least more definite indications of a particular time; a third considers both of these methods but is finally guided chiefly by physical criteria indicating displacement of the strandline and changed relations of land and water areas. The first and second depend either wholly or chiefly on strictly faunal criteria, the third follows the more comprehensive diastrophic method. Because of these differences in method stratigraphic taxonomy is burdened with striking incongruities of unit grouping. In one case the two adjoining systems, as, for instance, the Devonian and Mississippian, were originally divided solely according to paleontologic criteria; in another the diastrophic criteria of unconformity and change in character of deposits were the predominant factors that determined the location of the dividing line. Somewhat different though no less illustrative of the thought are those cases in which the deposition of clastic material adjacent to an obvious break in geologic history has been interpreted as the closing episode of the preceding period or epoch while similar occurrences in other parts of the scale have been described as the introductory stage of the succeeding time. Either condition may occur but they should be discriminated.

Perhaps even more common and troublesome are those inconsistencies which have resulted from the application of the diastrophic method in one area and the purely paleontologic in another. An instance of this is found in the Ordovician-Silurian boundary which was drawn in New York and in the Appalachian region generally according to the former method. In Ohio and adjoining states to the west and south, however, certain highly fossiliferous beds that are now known to correspond to deposits in New York that have always been classified as Silurian were placed in the Ordovician column because the fossils looked that way. In New York the Ordovician fauna ceases abruptly with the Pulaski; and this is succeeded by thick masses of sandstone and shale in which organic remains are unknown. But in Ohio the equivalent of the Pulaski is followed by the fossiliferous McMillan, and this by another group of beds—the Richmond—the latter of which passes laterally into the Lower Medina of New York. So long as our knowledge of the life of the Medina epoch was confined to the few things published in the New York reports, the rather strongly Ordovician aspect of the Richmond fauna completely masked its true age relations. Although the Richmond fauna now looks less like the Cincinnatian than it seemed to formerly, and the resemblance to the Upper Medina fauna is much clearer than it was, the case nevertheless shows how greatly our conclusions may vary under different methods of determination. Similar incongruities in the classification of the Paleozoic rocks of Great Britain are indicated by generalized lists of fossils published in recent text-books. Doubtless these are ascribable to similar miscorrelations of faunal and diastrophic criteria.

Considering the varying methods that have operated more or less independently in building up the present classification of sedimentary rocks, incongruous results are to be expected. In discussing these results decided disagreements are unavoidable, for if we do not agree in methods our conclusions must necessarily differ in corresponding degree. And yet the arguments on the various sides may be entirely logical and though leading to very different conclusions none can be justly accused of error in judgment. Each may be right from his viewpoint; and each may have excellent precedents for his mode of reasoning. But this does not help us to a systematic classification of geological formations. That desirable end is possible only under agreement; and the agreement must be on the matter of *method*. More than that, we must insist on *consistency* in the application of the chosen methods. This consistency in method, without which a really scientific classification of the sedimentary rocks, and thus of the geologic ages which they represent, is impossible, should pertain (1) to the criteria which shall determine where stratigraphic boundaries of whatever grade should be drawn, and (2) to those which shall determine which combination of units is to be ranked as a group, which as a series, and which as a system. In our opinion diastrophism affords the only means of finally attaining a reasonably accurate and systematically constructed classification—that is, diastrophism as defined in recent works in which the criteria and principles of stratigraphic taxonomy and correlation are fully discussed.[1]

For the reason that many of our "formations" are based on purely lithologic distinctions some may be of no greater importance in stratigraphic taxonomy than is accorded to "members," "lenses" or "beds." Others, on the contrary, may include beds representing two or more elsewhere readily distinguishable formations. In general practice, therefore, the latter are "groups," but they may be greatly inferior or much superior in time value to a technical group. Until we have acquired adequate information regarding the value of each of the several components of such a group, more or less uncertainty and inconsistency in the classification of these primary combinations of stratigraphic units is unavoidable. But this weakness of a growing science cannot excuse the absence of consistency in those cases wherein our information is adequate.

THE MAJOR DIVISIONS OF THE SILURIAN

THE CAYUGAN SERIES

As may be seen from the accompanying plate showing progress especially since 1895 in the classification of Silurian formations, geologists without exception have agreed in drawing a series boundary at the base

[1] Ulrich, E. O., Revision of the Paleozoic systems: Bull. Geol. Soc. America, vol. xxii, pp. 281-680, 1911: The Ordovician-Silurian boundary: Report 12th Session Intern. Geol. Congr., pp. 593-667, 1914; Correlation by displacements of the strand-line: Bull. Geol. Soc. Am., vol. xxvii, pp. 451-490, 1916.

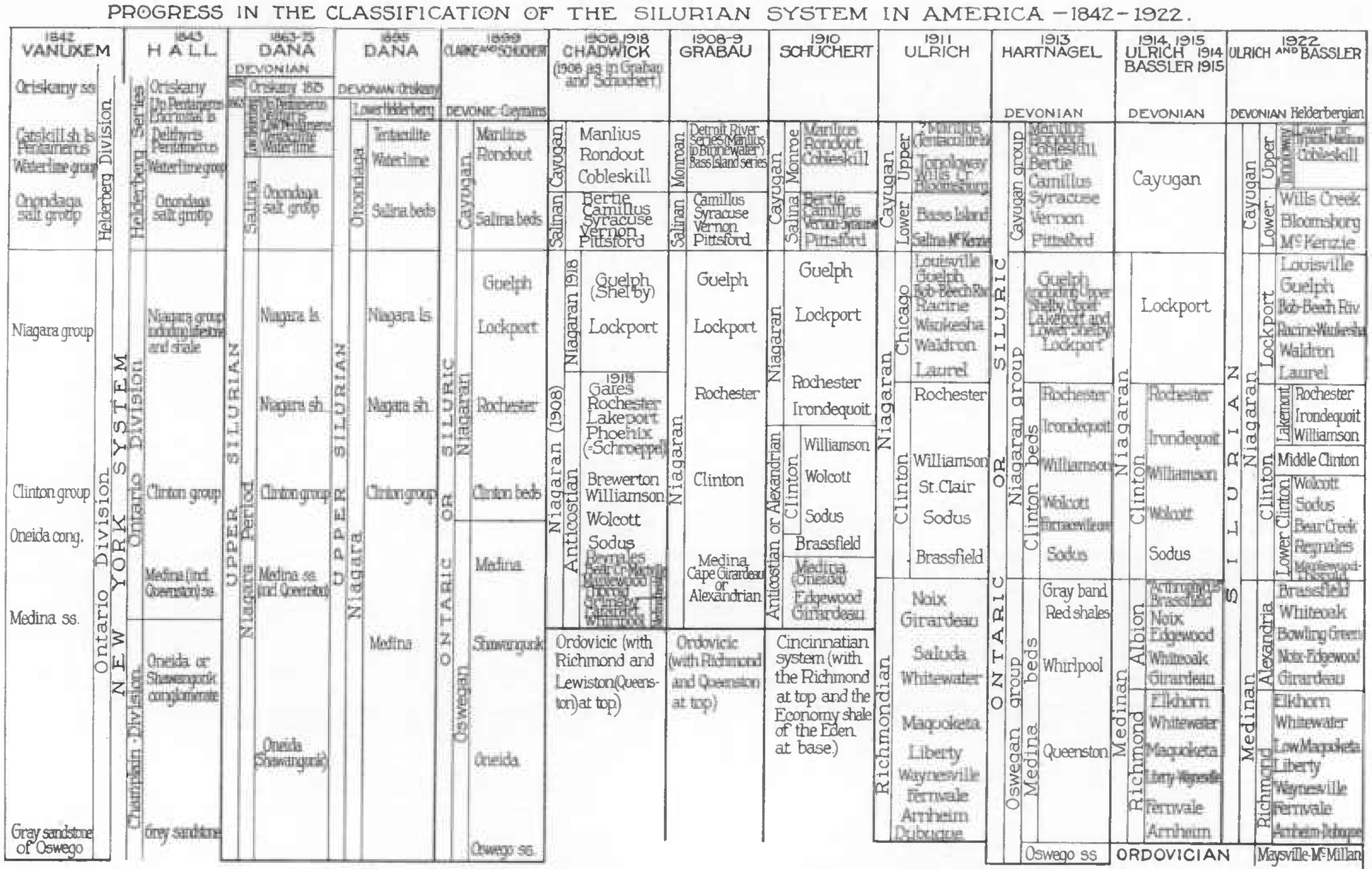

FIG. 2.—TABLE SHOWING THE VARIOUS CLASSIFICATIONS OF THE SILURIAN OF NORTH AMERICA.

of the Salina beds. There has been also very little difference of opinion regarding the discrimination of those beds which are to be called Salina from those that are still referable to the Niagaran series. As a rule the Guelph dolomite, which is easily recognized by its strikingly peculiar fauna, is placed at the top of the Niagaran. Evidently the Guelph invaded from the north; and the Niagaran series terminated in the north when the Guelph stage of the Lockport sea was withdrawn. The next succeeding shaly deposits, which are commonly supposed to have been laid down in greatly shallowed, pan-like, and almost lifeless remnants of the preceding sea, are sharply defined below and on the whole quite different. In most of the northern sections, therefore, we experience little difficulty in deciding just where the line is to be drawn between the two series.

However, in the middle and northern Appalachian region, where late Niagaran (Lockport) deposits are entirely unknown, there has been some difference of opinion. In Virginia, Maryland, and Pennsylvania the Clinton is followed by 150 to 250 feet of interbedded shales and limestones, containing a considerable marine fauna, to which the name McKenzie has been applied by Stose.[1] For some years prior to 1912 the McKenzie formation was thought to be of Niagaran age and was referred, together with the underlying Drepanellina clarki zone, to the Rochester and Upper Niagaran.[2] In the opinion of the present writers there is no valid ground whatever for this belief.

Of particular significance in this connection is the fact that in New York the Upper Niagaran or Lockport deposits pinch out entirely from west to east before reaching Herkimer County. Moreover, rocks of Lockport age are wanting entirely in the Appalachian region to the south of Maryland. Indeed, in east Tennessee the rule is absence of all Devonian and Silurian deposits above the Medinan. Therefore, to recognize Niagaran in the McKenzie of Maryland would require the assumption

[1] Stose, G. W., Pawpaw-Hancock folio, 179, Atlas U. S. Geol. Survey, field ed., p. 40, 1912.

[2] Schuchert, Charles, On the Lower Devonic and Ontaric Formations of Maryland: Proc. U. S. Nat. Mus., vol. xxvi, pp. 413-424, 1903.

Prouty, W. F., The Meso-Silurian deposits of Maryland: Am. Jour. Science, vol. xxvi, pp. 563-574, 1908.

that the rule for the Appalachian region failed in this case. We say assumption and mean that the assignment of the McKenzie to the Niagaran is possible only on the basis of position in the section and original coextension of Silurian seas; there is a Rochester fauna beneath it and none can doubt the Salina age of the Wills Creek formation which overlies it.

But the absence of the Lockport in eastern New York is not due to erosion prior to its overlap by the Salina. Nor is there any evidence to show that the Lockport was deposited in the Appalachian region between eastern New York and Tennessee and then removed by erosion before Cayugan sediments were laid down in the same region.

Wherever deposits of Cayugan age are found in the Appalachian region they begin with beds that are clearly of the age of the McKenzie; and these are followed by younger beds of the Cayugan series. That the McKenzie represents the first deposits of a new series of Atlantic invasion is established by the fact that the age of the immediately underlying Clinton beds varies from place to place. Thus, whereas in Pennsylvania and Maryland the McKenzie lies on the Drepanellina clarki zone of Rochester age, at Big Stone Gap in southwestern Virginia it lies on the next lower Mastigobolbina typus zone and near Sneedville, Tenn., on the still lower Bonnemaia rudis zone. With the evidence in hand it is impossible to escape the conviction that during Upper Niagaran or Lockport time the Appalachian Valley region was above sea level.

It is rather commonly supposed that in Maryland the lower part of the McKenzie contains a number of species that are also found in the underlying Drepanellina clarki zone. That this supposition has some basis in fact is readily conceivable in view of our belief that the faunas of both these zones invaded this region from the same part of the Atlantic realm. Still we doubt very much that this supposed community of species is as great as certain lists of fossils indicate and also that in the unquestionable instances the specimens of the two invasions are not distinguishable. As a rule fossils occur in both quite to the plane of contact, and these, especially the Ostracoda, in no instance proved strictly the same on both sides of the boundary.

Viewing the McKenzie fauna as a whole its relations to that of the Wills Creek is decidedly closer than to that of the underlying Drepanellina clarki zone. This is shown especially by comparison of their respective ostracod faunas. Drepanellina, the most distinctive of the genera of the Niagaran zone, has passed out, Paraechmina is much reduced in representation and that of the Klœdenellidæ greatly increased and the species of the family are easily distinguished from their Rochester relatives. Similarly the single species of Klœdenia in the Drepanellina zone is clearly different from the four species of the genus in the McKenzie. On the contrary, in the much less varied ostracod fauna of the Wills Creek the two species of Klœdenellidæ are very similar to—perhaps merely varieties of—McKenzie species, and the sole species of Klœdenia is regarded as the same as *K. normalis*. Further, the McKenzie fauna includes a species of Kyammodes, the first of its genus, the second being in the Tonoloway. Finally, Leperditia, which is exceedingly rare in the Drepanellina zone, is abundantly represented in the McKenzie by species that are to be compared only with Cayugan forms of the genus.

On such grounds as these we were finally convinced of the entire propriety of Ulrich's previous reference of the McKenzie formation to the base of the Cayugan series as developed in the Middle Appalachian region. At the same time all doubt was removed regarding the absence of deposits of Lockport age in the Maryland and adjoining states.

Admitting the Atlantic derivation of the McKenzie fauna, and also the Cayugan age of the deposits, we have two facts that cast grave doubt on the prevailing conception respecting the residual character of the Salina waters of New York. It appears more likely that the latter also came in from the Atlantic at a time subsequent to the complete withdrawal of the Guelph sea. Unqualified corroboration of this view is found in the fact that the Salina deposits in New York widely overlap the Guelph to the east and south. In fact the Salina greatly exceeds the Guelph in areal distribution in America, which, even if we concede a largely continental origin for the Salina, could scarcely be if the Salina really represented deposition in merely shallowed remnants of the preceding late Niagaran sea. But a full discussion of this subject is beyond the purposes of this paper. These are fully satisfied by the suggested probability of important diastrophic movements during the interval between the Niagaran and the Cayugan. These brought about a return to conditions as to direction of movements and resulting invasions simulating those of the preceding Clinton stage. Namely, during the Clinton and at least the Lower Cayugan the marine invasions came in mainly from the north middle Atlantic and affected little besides the Appalachian and Alleghany plateau areas. During the intervening Lockport ages, however, the movements consisted of alternate north and south tiltings which resulted in Arctic and southern invasions that were mainly confined to more interior areas of the continent.

Though unanimity of opinion prevails among geologists respecting the taxonomic value of the Niagaran-Cayugan boundary, it will be observed that at least two—Chadwick (1908) and Grabau (1908-9)—entertain views regarding the post-Niagaran part of the Silurian that are not generally shared by others. Namely, the authors cited divide the "Onondaga period" of Dana, which is the same as the Cayugan group or series of Clarke and Schuchert, into two series corresponding in taxonomic rank to the Niagaran series. As we see it there is no warrant for the recognition of two distinct series in the Silurian above the Niagaran. If there were, then we should for precisely similar reasons divide the Mohawkian and the Cincinnatian of the Ordovician system into two series each. Detailed comparisons of the two groups of each of these two Ordovician series with the two groups of Clarke and Schuchert's Cayugan bring out some striking similarities in their respective diastrophic histories. Unfortunately space is lacking for their discussion. All we may say here is that in each of these divisions—the Mohawkian, the Cincinnatian and the Cayugan—a sequence of movements is determinable that stamps them severally as of the grade of a series.

Though Chadwick and Grabau may question the above statement it does not seem possible that they can successfully defend their position when they at the same time advocate a Niagaran that is made to include a part of the Medina series. For surely the Niagaran, even in the restricted sense in which this term is employed by Clarke and Schuchert.

and by most stratigraphers since 1899, is fully equal in volume of deposits and in sequence of diastrophic and faunal history to the combined Salinan and Monroan of Grabau and the corresponding Mesontaric and Neontaric of Chadwick. The Salina and the Monroe are most probably distinguishable groups of the Cayugan series of Clarke and Schuchert but their taxonomic importance is most certainly not greater than that of the Clinton and Lockport groups of the Niagaran series, or of the Richmond and "Upper Medina" or Alexandria groups of the Medinan series, or of the Black River and Trenton groups of the Mohawkian series. Evidently, then, Chadwick and Grabau's proposal to promote the designation Salina to the rank of a series term is distinctly inconsistent with prevailing conceptions respecting the relative values of generally recognized group and series divisions of the Ordovician and Devonian systems. And consistency, as has been said on a preceding page, seems one of the foremost essentials of systematic classification.

The Cayugan series therefore is retained in the sense in which the term was proposed by Clarke and Schuchert in 1899. But we may well compromise with opposing views by recognizing two groups of the Cayugan series. For the lower of these the term Salina group is probably appropriate. However, pending a fuller knowledge of the relations of the Bass Island of Ohio to the Salina of New York we hesitate to commit ourselves to it. We are doubtful also regarding a large part of the Monroan of Michigan and Ontario, which contains fossils that remind too strongly of Devonian types to be accepted as Silurian without further study. Provisionally, therefore, we prefer to use the non-committal designations Upper and Lower Cayugan.

THE NIAGARAN SERIES

The term Niagaran period or Niagaran series has been in general use for more than 50 years. But the meaning attached to the name has varied from time to time and also according to the individual views of authors. The broad definition given it by Dana, according to which it included everything between the top of the "Hudson epoch" and the base of the Salina, seems not to have recommended itself to the majority of geological practitioners. Heads of state surveys used it frequently in generalized tables and charts of geological formations, but when it came to the description and discussion of the formations the term was seldom employed except in the narrower of the two senses in which it was used by Dana. They saw no practical occasion for the use of "Niagara period" when it seemed entirely feasible and more accurate to discriminate the two lower groups—Clinton and Medina—from the upper or true Niagara group of Hall's original classification. Besides, the double meaning of the term necessitated undesirable qualification and at the best led unavoidably to confusion. In the last 25 or 30 years of the past century, therefore, the term Niagara was seldom used in stratigraphic nomenclature except for beds regarded as younger than the Clinton.

As time went on it was found that even this usage of the term Niagara had objectionable features. It became clear that the Niagara limestones of Wisconsin, Illinois, and Iowa, also of Ohio, Kentucky and Tennessee, were only in part or not at all the same as the Niagara limestone of New York. Nor were the "Niagara shales" the same as the New York Niagara (Rochester) shale. Some appeared to be younger, others older. We needed, and as occasion arose, we applied other names to these more or less distinct stratigraphic units. But there yet remained the necessity for a general term by which we may refer to the varying units as a whole, a term based on general similarity of faunas and of geologic history.

This necessity was recognized by Clarke and Schuchert in 1899 when they revived the old local terms Rochester shale and Lockport limestone to take the place of Niagara shale and Niagara limestone and proposed Niagaran for the desirable broader designation as indicated by the fossils. In a way their Niagaran is a judicious compromise between the impracticable and unnatural Niagara period of Dana and the artificial association which he called the Niagara group. It is not only a happy solution of the nomenclatural difficulty but an admirable and perfectly natural association of formations in New York. And the last consideration is of high importance so long as the New York section remains the standard for comparison.

That the Clinton is more intimately related to the overlying rocks in New York than to the underlying Medina formations should be clear to anyone having a comprehensive knowledge of the stratigraphy and faunas of the concerned formations. Hall recognized this fact very well when he says:[1]

"In its western extension the Clinton group assimilates in character to the Niagaran group. At the same time the group . . . . loses the fossils which were typical of it and becomes charged with fossils peculiar to calcareous strata. Thus, while we find its lower beds, from Wayne County westward to the Niagara River, characterized by peculiar fossils, we find the upper beds containing many species which pass upward into the Niagara group. Indeed, there is no line which can be designated between these two groups, which shall mark the limits of the organic products."

And this statement was made under the erroneous impression that the Rochester shale of western New York is subsequent in age to the top of the typical Clinton in the central and eastern parts of the state. Also at a time when very little was known of the fauna of the upper part of the Clinton in Oneida County; and before the work of Ringueberg, Sarle, Hartnagel, and Chadwick had fully demonstrated the essential unity of the faunas of the Irondequoit limestone and the Rochester shale. Furthermore, the Rochester fauna is above all others the original type of the Niagara fauna. It was then, and is yet, the central standard; and the proof that the zone of the Rochester shale is represented by sandy and ferruginous beds in the typical section of the Clinton cannot affect the rights of the Rochester fauna to the distinction of being the most typical expression of the life of the Niagara epoch of Dana and of the Niagaran group or series of Clarke and Schuchert. The recent discoveries respecting the relations of the Rochester to the Clinton only fasten these rights more securely.

Aside from the Rhinopora verrucosa fauna of the Brassfield and Cataract formations, which contains many actual forerunners of Rochester species, there is really very little in the Medina fauna that reminds of average Niagaran fossils. On the contrary we see many things that recall preceding Ordovician types. This alliance with ancient forms is,

[1] Paleontology New York, vol. ii, p. 3, 1852.

of course, most clearly exhibited by the Richmond Medinan faunas, but it is still readily apparent in such later stages of the series as the Albion sandstone at Medina and Lockport, N. Y. However, when we have passed upward in the section to the Clinton the general aspect of the fauna has changed so greatly that the Ordovician reminders are thenceforth practically negligible.

Stratigraphically, too, the relations of the Lower, Middle, and early Upper Clinton to the Rochester, and thus to most typical Niagaran, are very close. Chadwick (1918) admits these relations, in part openly, in part tacitly, by associating not only the Irondequoit with the Rochester, as Schuchert and others have done, but also the Williamson shale. It is indicated besides by his doubtful expressions regarding the yet older fauna of the Wolcott limestone. The main reason for these apparent and actual faunal alliances is explained by us in a subsequent chapter as due to recurrent invasions of the southern early Silurian fauna; but however explained these alliances are real and manifest enough to cause much trouble in recognizing particular zones. As we have seen, Hall already admitted them for western New York; and in central New York the intimacy of these relations is even greater. Indeed, we question if it is possible to draw lines at Clinton, N. Y., that would indubitably discriminate either the Rochester or the Irondequoit equivalent from the remainder of the Clinton. It would be no less difficult to draw such lines in Pennsylvania and Maryland. Here, as in central New York, we recognize faunal distinctions that serve very well in separating the Lower and Middle Clintons from each other and both from the Upper. But how much of the Upper Clinton corresponds to the Irondequoit limestone and how much to the Rochester shale may never be certainly determined. On the other hand there is not the slightest difficulty in distinguishing the Clinton from the Medina faunas and formations in the mentioned areas. Uncertainty obtained for a time only in those areas in which the Brassfield and certain facies of the Cataract are developed.

It is true, as just indicated, that Medinan deposits have often been determined as Clinton. We see such misidentifications in Ohio, Kentucky. and other interior areas; and in the Appalachian region we have a very prominent instance in the Rockwood formation of eastern Tennessee. But these errors were occasioned not so much by misinterpretation of faunal evidence as by the formerly almost universal belief in continental seas of great extent. Most of the important formations in the New York section were supposed to extend great distances westward and southward in unbroken though uneven sheets. If a section in Ohio contained beds that were certainly identified as Niagara limestone then the geologist looked for a shale beneath the limestone that he might call it Niagara shale. And he did call it so despite the fact that the shale contained typical Clinton fossils. Next, it was desirable to recognize a Clinton and so the "Ohio Clinton," which is really of Medina age, took that place in the Ohio column. Under this certain reddish clays and sands of limited extent and thickness were called Medina. Thus, with the underlying "Hudson River," "Utica," and "Trenton" the Ohio geological scale finally was made to appear as duplicating the New York standard.

But forced miscorrelations like these should not leave the impression that proper correlations in these cases are unusually difficult. In fact they are not; had the sections been studied and compared solely from the paleontological standpoint, and without regard to prevailing ideas as to the wide extent of the seas in which the sediments were laid down, truer results must have obtained. And had the faunal data been collected so that they might have been used to identify particular beds or layers from place to place rather than according to formations, that is, if the fossils had been collected so as to bring out details in stratigraphy and areal distribution and not only to identify broad and supposedly locally varying faunal aggregates, it would not have remained for the present members of the New York Survey to prove that the relations of most of the formations in eastern New York to those in the western half of the state are really quite different from what they were supposed to be.[1] If the older

[1] Doubtless another important reason for the misconceptions lies in the fact that each of the great geologists of the first survey of New York confined his detailed stratigraphic work to his own district. Had their districts been divided by parallels and either Vanuxem or Hall studied the area between Niagara River and the eastern border of the state, American stratigraphy would have had a very different and probably much better beginning.

generation of geologists had realized that it is the rule and not the rare exception for formations to be confined to relatively small basins and narrow troughs, and that the correspondingly limited deposits in these distinct basins, though seeming to occupy the same position in the stratigraphic column, are yet very commonly not of the same age, or if they had understood that thinning of stratigraphic units is more generally indicative of growing seas and overlapping of deposits than of local inequalities in the rate of deposition, many of the erroneous correlations which now burden the science would have been avoided. But as they did not appreciate these conditions there is nothing to do but to correct the errors as we come to them.

Considering, first, the faunal and stratigraphic break that separates the Clinton from the Medina throughout the Appalachian and more interior regions, second, the more important fact concerning the approximate equality from the taxonomic standpoint of the formations embraced in, and those elsewhere which correspond to, the Medina series of New York on the one hand and the Niagaran series of Clarke and Schuchert on the other, and third, the apparent coordinates of the Medinan and Niagaran series when compared with the Cayugan, the separation of the Niagaran period of Dana into two series equal in rank to the Cayugan (Onondaga period of Dana) seems fully justified by the facts as we now know them. Chadwick's attempt in 1908 and in modified form again in 1918 to partially reestablish Dana's Niagara period by the inclusion of the Upper Medina or Albion group in his Eontaric or Niagaran seems to have been based on two perhaps excusable misconceptions, (1) lack of information regarding the true significance and stratigraphic value of the Albion or Upper Medinan of New York which has only just become apparent through more recent investigations of the "Rockwood formation" of east Tennessee, the Anticostian series in the Island of Anticosti, and the Alexandrian of Illinois and Missouri, and (2) the acceptance of prevailing views regarding the proper position in the stratigraphic scale of the Richmond to which he referred the lower Medina or Queenston (Lewiston). Similarly inadequate information probably lies at the base of Grabau's Niagaran which differs in no essential particular from Chadwick's use of the term. Schuchert's 1910 classification restricts the Niagaran to beds above the Williamson shale of the Clinton. Except that the Irondequoit limestone is classified with the Rochester shale, Schuchert's Niagaran is the same as Dana's Niagara epoch. As no reason is given for this departure from the Clarke and Schuchert (1899) definition of Niagaran it seems unnecessary to discuss it. Besides it appears from the much broader significance given the term in his and Twenhofel's table of formations on Anticosti Island,[1] published later in the same year, that Schuchert had not yet made up his mind regarding the matter. Ulrich's 1911 use of the term differs from Clarke and Schuchert's 1899 definition only in that it is made to cover the "Brassfield," which term was provisionally adopted for the late Medinan Ohio Clinton or Rhinopora verrucosa zone. Finally, in the Hartnagel classification of New York formations (1912) the term Niagaran has the same significance given it by Clarke and Schuchert in 1899 and by Clarke in 1903.

The Clinton and Lockport Groups of the Niagaran

Including the Maplewood shale, the Oneida conglomerate, and most probably also the "Gray Band" or Thorold sandstone at the base and the Rochester shale at the top, the Clinton obviously constitutes a *group* in stratigraphic classification. In our opinion the Clinton group thus constituted ranks in stratigraphic and time values with the combined overlying formations of the Niagaran series for which Ulrich proposed the term Chicago group[2] that was later withdrawn by him in favor of Lockport group.[3] The importance of the latter is indicated by the great thickness of the dolomite limestones of this age in eastern Wisconsin and by the large and varied faunas found in at least three of the four formations into which the group is there divided. The faunas of the several formations are sufficiently distinct to suggest interruption of the process of sedimentation by withdrawal of seas at the close of each. During these

[1] Bull. Geol. Soc. America, vol. xxi, pp. 684-685, 1910.

[2] Ulrich, E. O., Revision of Paleozoic systems: Bull. Geol. Soc. America, vol. xxii, p. 560, and Correlation table II, 1911.

[3] The Ordovician-Silurian boundary: Rept. 12th International Geol. Cong., Correlation chart, opp. p. 666, 1914.

interruptions it is thought that deposition took place in Kentucky and west Tennessee where a similarly broken and oscillating sequence of beds is found.[1] In Tennessee, furthermore, the late Niagaran rocks are not magnesian as in the north, but consist of nearly pure limestone and calcareous shale. The faunas also in the two areas, though of the same classes, are very different in generic and specific expression. In the "Revision" just cited Ulrich endeavored to account for these striking differences in distribution of rocks and faunas by a theory of alternate tilting of the continental platform (*op. cit.*, pp. 406, 559). According to this theory the continent was at times tilted toward the north, permitting invasion of boreal faunas; and the times when this condition obtained alternated with other times when the opposite condition of southward tilting and invasion of southern waters occurred. Obviously this conception involves practically a doubling of the time that would be allotted to the Niagaran epoch on the basis of either the Wisconsin or the west Tennessee sequence. Similar oscillations and alternating reversals of direction of tilting, but in this case in northeast and southwest directions, will be shown to have occurred during Clinton time.

Despite the great time value that must be credited to the Lockport group, whether the above theory is accepted or not, the deposits of the Clinton group seem to indicate in their aggregate a scarcely inferior range of time. The great volume of Clinton deposits in the Appalachian region is an impressive fact even though they consist chiefly of clastics. But the material is almost entirely in a fine state of division; and it includes at the top a considerable thickness of limestone. The group, therefore, as developed in Virginia, Maryland, and Pennsylvania, doubtless required a long time to deposit. We may add further that the mass of 1200 feet or so of Clinton beds in Virginia does not, in our opinion, represent continuous deposition. In the first place there is no sign of the Pentamerus limestone fauna in the thickest of the Virginia sections. Absence in this case probably means interruption of sedimentation and a

[1] For the latest classification of the Silurian rocks of West Tennessee, see Pate, W. F., and Bassler, R. S., U. S. Nat. Mus. Proc., vol. xxxiv, pp. 407-432, 1908.

hiatus in the section. Then there is the St. Clair limestone in Arkansas, the typical part of which is almost certainly of Clinton age. However, it carries a fauna that has no parallel elsewhere in America. The St. Clair may be contemporaneous with some part of the Virginia Clinton; but then again it may represent another interruption in Appalachian sedimentation. Compared in this manner it seems reasonably certain that the Niagaran series is properly divisible into two groups, the Clinton and the Lockport, and that these two groups are practically equal in rank and time values.

Comparison of the various classifications of Silurian rocks shows that authors have varied greatly in the past 25 years in their respective methods of subdividing the Niagaran series of Clarke and Schuchert. Of the 12 columns, the fourth (Dana, 1895) is nearer than any of the others, in the matter of major divisions, to the last column which represents the classification now proposed. Dana recognized two groups, the Clinton and the Niagara, which correspond essentially to the Clinton and Lockport groups of the proposed arrangement. They differ only in a matter of detail respecting the constituents of the Clinton group, Dana having followed then prevailing opinion in referring the Rochester (Niagara) shale to the upper group, whereas we place this shale beneath the top of the lower group. That the horizon of the Rochester shale is actually included in the typical Clinton of central New York was admitted and is yet believed by the officials of the present New York Survey (see the 1912, or Hartnagel edition of Handbook 19); and the faunal and stratigraphic evidence on which this relation is based and which renders the desire to restrict the Clinton to underlying beds practically impossible is presented in all its phases on following pages of the present contribution. But Dana, in common with all geologists prior to the discovery of this fact, placed the whole of the typical Clinton into the lower group, hence the removal of the Rochester shale from the upper group to the lower resolves itself simply to a question of minor correlation. Furthermore, the Clinton group has all along seemed the more fixed of the two, both as to its stratigraphic position and equivalents and its nomenclature. Besides, with the disproportionate advance in knowledge respecting the divisions of the upper group their taxonomic importance was more and more emphasized while the Clinton stood still, and standing still its apparent rank became proportionally less. Thus, in the Clarke and Schuchert and the Chadwick classifications, the Rochester, Lockport, and Guelph formations are each given the same rank as the Clinton, an injustice that culminated in the Grabau classification in which the Rochester seems to rank with the combined preceding Silurian deposits down to the base of the "Medina" (Albion). Whether the mentioned authors really believe that the Rochester shale, and the Lockport limestone (exclusive of the Guelph) in the other, rank equally with the Clinton in stratigraphic taxonomy cannot be said, but as tabulated by them it certainly appears so. In either case, however, there is a lack of that coordination of units which is so essential in a systematic and scientific classification.

Much of this inconsistent grouping and confusion might have been avoided if someone had only remembered that the type section of the Clinton is in Oneida County, New York, and not in the Genesee Valley. Had some competent and wholly unbiased stratigrapher spent only a week on the type section it is scarcely conceivable that he would have failed to correct the long-prevalent error that placed the Rochester shale entirely above the top of the Clinton; and this correction alone would have removed the main cause of the confusion that has so long prevented the proper and consistent orientation of the Niagaran formations. But we know more of the facts now and are ready to make a new start. We know them not only in New York, where the upper or Lockport group is not fully developed, but also in Wisconsin and west Tennessee, where the upper group is much better represented, and in the Appalachian Valley where the Clinton attains its greatest thickness. Basing the new effort on this fuller information, and with settled convictions regarding the desirability of consistency in grouping, it is perhaps not too much to hope that the revised classification herewith presented will commend itself to systematic stratigraphers.

As mentioned above the term Chicago group was used for the Upper Niagaran group by Ulrich in 1911 on the Silurian correlation chart of his Revision of the Paleozoic systems. Some special name for this group seemed desirable, and none of the New York names as generally used appeared to fill the requirements. Clarke, Schuchert, Chadwick, Grabau, Hartnagel, and others who devoted time to the classification of the Silurian rocks in New York invariably divided the Niagaran above the Clinton into three apparently coordinate divisions, the Rochester, Lockport, and Guelph. Following the subordination of the Rochester to the Clinton and the recognition of the relatively greater value of the boundary between the Rochester shale and superposed dolomitic formations that in New York constitute the Upper Niagaran, the question arose which if any of the established New York terms might be employed as a proper designation for the upper group. In view of general practice none of them seemed to fit the case. In practice all writers insisted on the recognition of the Guelph as a distinctly younger stratigraphic unit than the Lockport. Under the circumstances the easiest solution of the difficulty was to go elsewhere for a name that would cover all the beds between the top of the Rochester, hence the top of the Clinton group—as conceived by Ulrich, Hartnagel, Bassler, and others—and the top of the Niagaran series. At once the strong and rather well-known development of the corresponding Upper Niagaran deposits in Wisconsin and northern Illinois came to mind; and here the name Chicago group quickly suggested itself as an appropriate and altogether satisfactory solution of the difficulty.

However, on further reflection one factor of the problem stood out prominently as not having received the attention that its claims demanded. This fact, namely, is the well-established presence of the Guelph fauna in Orleans County, New York, within 12 miles of Lockport, hence well within the area that may justly be regarded as containing the typical expression of the Lockport dolomite. The Guelph fauna has also been found to the east at Rochester where most of the fossils described as belonging to this fauna by Clarke and Ruedemann[1] were collected. Its horizon has also been established in the gorge section at Niagara

[1] Clarke, John M., and Ruedemann, Rudolph, Guelph fauna in the State of New York: Mem. V, New York State Museum, pp. 1-187, 1903.

Falls. At all of these and other places in New York it occurs in the upper part of the series of dolomitic limestones to which the term Lockport limestone was originally applied. Whatever of stratigraphic significance we may give to the one or more zones containing the Guelph fauna the fact remains that these zones are included in the Lockport.[1] It is for this reason mainly that we have decided to abandon the term Chicago group and to use instead the older name Lockport for the upper of the two groups into which the Niagaran series is here divided.

THE MEDINAN SERIES

When it became evident that the New York Survey is not inclined to accept any material modification of the significance originally assigned to the term Medina sandstone the senior author in 1914 gladly withdrew the support he gave in 1911 to the attempt of certain geologists—Chadwick, Grabau, and Schuchert—to restrict the name to beds of the age of those at Medina and Lockport in New York, from which Conrad and Hall procured the molluscan fossils ascribed to the Medina in the second volume of the Paleontology of New York, 1852. Nothing having appeared in the meantime tending to weaken our convictions in this matter we use the term Medina in the perfectly logical broad sense given it by Vanuxem and Hall. As the deposits originally included under this name in New York, and those corresponding to them in other regions, are divisible into two well-defined groups the Medina becomes a series. According to custom the name takes the form of Medinan when used in the time scale.

Except that we do not include the Oswego sandstone, the Medinan is the same as the Oswegan of Clarke and Schuchert. It should be remembered, however, that when Clarke and Schuchert proposed Oswegan they

[1] The terms Lower Shelby and Upper Shelby dolomite used by Clarke and Ruedemann as designations for the two zones of the Lockport dolomite in which the Guelph fauna is found in western New York obviously were not intended as formally proposed names of distinct formational units or of members of the Lockport. In fact even the name Lockport as employed by these authors in the work just cited refers to the faunal content of the beds rather than to a definite formational unit.

at the same time dropped the minor term Oswego sandstone, because they regarded the "gray Oswego sandstone" "as a part of the arenaceous sedimentation of the Medina-Oneida stage." Now, since the Oswego sandstone has been shown to be a distinct stratigraphic unit underlying the Queenston, it is added to the base of the Oswegan in the Hartnagel classification (1912). Chadwick, Grabau, Schuchert, Foerste, and Ulrich, however, are agreed in referring this gray sandstone to the Maysville group of the Cincinnatian series. The evidence, physical and faunal, so far as then procured, was presented by Ulrich in his 1914 discussion of the Ordovician-Silurian boundary. Other evidence, all of it favoring the conclusions published in 1914, has come to hand since.

The Medinan of the present work is also very nearly the same as the Richmondian series in Ulrich's "Revision" (1911). There is a difference at the top, the upper or "Brassfield" member of the Upper Medina being referred to the Clinton on that occasion and now to the Medinan. Another difference is suggested at the bottom, namely, in the "Revision" the Lower Medina or Juniata-Queenston was placed inadvertently beneath instead of in or opposite the Richmondian, an error fully corrected in Ulrich's 1914 paper on the Ordovician-Silurian boundary.

Clarke and Schuchert's term Oswegan is rejected in favor of Medinan primarily on the ground that the former name was already in legitimate use for a properly established and valid formation. Vanuxem employed it first in 1839 when he spoke of the "red sandstone of Oswego," referring at the time to Medinan deposits that seem to be of the age of the Queenston. Though this use of the name was abandoned in favor of Medina in the final report on the Third district, published in 1842, it was retained in this report by Vanuxem for the "gray sandstone of Oswego." There can be no question as to Vanuxem's intention at this time. He was convinced that the gray sandstone constituted a distinct bed between the Pulaski beneath and the red shales and sandstones of the Medina above; and it was for this intermediate mass of sandstone that he wished to preserve the name Oswego. Hall's misapprehension concerning the equivalence of this gray Oswego sandstone and the Oneida conglomerate, an error that prevailed among American geologists generally for more than 60 years, could not invalidate Vanuxem's correct observations regarding these formations. Therefore, the term Oswego sandstone, Vanuxem, 1842, though perhaps almost forgotten, was nevertheless valid and prohibitive of other uses in stratigraphic nomenclature in 1899 when Clarke and Schuchert proposed the term Oswegan.

The Richmond Group

That the term Richmond formations constitute a good group will scarcely be denied by those who have had the opportunity to study the many distinct and widely recognizable faunas and formations that fall into this stage of oscillating seas. The geographic pattern of North America doubtless varied greatly from time to time during the course of the Richmond, but the history of the movements that caused these changes in distribution of land and sea areas and the consequent modifications of the life in the shifting continental basins are extremely complex. An adequate discussion of the data in hand that bear on this history would alone require a volume. For present purposes it must suffice to say that northern and southern invasions alternated repeatedly and that some of these submergences were among the greatest to which the continent was subjected during the Paleozoic eras. Considered from the standpoint of diastrophism the Richmond is more closely allied to succeeding Silurian history than to the preceding Ordovician. The facts in the case were discussed in considerable detail by Ulrich in 1914 (Ordovician-Silurian boundary). Nothing has appeared in the meantime to invalidate the conclusions then presented. On the contrary much new and in every instance definitely corroborative evidence has accumulated since 1914.

Comparison of the 9th and 11th columns of the accompanying table shows wherein the Richmondian series of the 1911 classification differs from the Richmond group of the arrangement first proposed in 1914 and maintained to the present time. In the former, two Upper Medina formations, the Girardeau and Noix limestones of Missouri, are added to the top to make the Richmondian series. In the latter the upper boundary of the Richmond is dropped to the position originally designated as the top of the group in the typical section at Richmond, Ind. Regarding this change it should be said that in 1911 our information concerning the Upper Medina was greatly inferior to what it has become since the opportunities to make detailed studies of the typical Medina formation of New York and of the "Rockwood formation" of east Tennessee were offered. At that time we had only a very imperfect conception of the important rôle played by the Upper Medina in Silurian history. In fact we had no reason to doubt the generally accepted Clinton age of the Rockwood. The discovery that the typical Rockwood is all pre-Clinton immediately placed a very different aspect on the problem of classifying the early Silurian formations. Instead of two relatively unimportant fossiliferous zones supposed to correspond approximately to the Upper Medina of New York we now had a complex group evidently ranking quite fully with the underlying Richmond group. The final proof that the Juniata-Queenston is of Richmond age came at the same time. This was found to the north in southern Ontario where the Queenston was observed passing laterally into and interfingering with indubitably Richmond fossiliferous beds, and to the south in east Tennessee where the Juniata passes laterally into the more limy marine beds of the Sequatchie formation, the fossils of which also stamp it as of Richmond age. And thus the stage was set for the Medinan series with two groups, the Richmond below, the Albion or better, the Alexandrian, above.

The subdivisions of the Richmond are taken chiefly from the Indiana section. Three Illinois and Iowa members are inserted in the scale where they seem to fit best. The Dubuque is put at the bottom only provisionally. Too little is known of its fauna to permit a definite placement at this time. The Fernvale, however, is definitely known to succeed the Arnheim at Clifton, Tenn. The relations of the Maquoketa to the Indiana Richmond are not so readily determined. However, we know that it is underlain in southern Illinois by the Thebes sandstone and that this lies unconformably on the Fernvale. We know also that the typical Maquoketa is succeeded in Iowa and Wisconsin by at least two other Richmond formations. It is therefore inserted at the horizon of the most pronounced faunal break in the Richmond sequence of Indiana, namely, between the Liberty and the Whitewater. Doubtless other intercalations will be made when the Richmond deposits in the upper Mississippi Valley, in Manitoba and in the far West shall have been fully studied.

The Alexandrian Group

The desirability of a geographic designation for that part of the Medina of New York which overlies the Queenston shale or sandstone has long been felt. Commonly it has been distinguished as the "Upper Medina" and in recent years certain authors have spoken of it as the "typical Medina." This, together with the rather commonly entertained objection to the inclusion of the Richmond in the Silurian, naturally led to the ill-advised attempt to restrict the term Medina to the upper beds. Fortunately the Director of the New York Survey has consistently opposed the latter step; and now by the proposal of a new term—Albion sandstone—for the Upper Medina of New York he has, as we hope and believe, effectually blocked these attempts to restrict the original meaning of the broader term.

In western New York the Albion is divisible into at least two members or formations. The lower of these is the Whirlpool sandstone. The upper is not a single formational unit but comprises representatives of several distinguishable members or formations. At Niagara Falls the presence of two and possibly three members above the Whirlpool sandstone is suggested by comparison with sections to the east and northwest. One of these is well developed and highly fossiliferous at Medina, another —distinguished by the Rhinopora verrucosa or Brassfield fauna—constitutes the greater part of the Upper Medina (Clinton of Logan) in Ontario, while the third (Thorold sandstone) embraces the heavy-bedded layers of the Arthrophycus harlani zone at the top of the Albion. A part, if not the whole, of the last is believed to be strictly referable to the Clinton group. Regarding the two faunal zones between the Whirlpool and the Thorold sandstones there is some difference of opinion as to which, if either, is the older. Schuchert[1] describes the Cataract forma-

[1] Shuchert, Charles. Medina and Cataract formations of the Siluric of New York and Ontario: Bull. Geol. Soc. America, vol. xxv, p. 294, 1914.

tion of Ontario as passing laterally into the Medina (Albion) and thinks he recognizes the Medina fauna above the Cataract fauna in the section at Niagara Falls. Judging from the stratigraphic relations of the two faunas in east Tennessee the fossil bed at Medina should be older than the Rhinopora zone. We also believe that both faunas are sparingly represented in the Niagara Falls section, but it seems to us that what there is here of the typical Medina molluscan fauna is in the lower part of the Albion rather than in the upper half. Unfortunately, the fossil evidence now in hand from Niagara Falls is insufficient to prove either view. However this question may be finally answered it is certain even now that these two sets of beds are distinct in their diastrophic and faunal histories. In view of these facts and possibilities we are probably warranted in saying that the Albion as developed in New York and Ontario comprises at least three members or formations differing from each other very decidedly in geographic distribution and fossil contents. The Albion, therefore, has even in New York the attributes of a group.

The real importance of the group is more clearly indicated by the aggregate volume and varying distribution of the corresponding upper Medina deposits comprised in the typical Rockwood formation of east Tennessee and northeastern Alabama. These Appalachian deposits are fully described by the senior author in another work that may be published in the near future. Whether these estimates are underrated or overdrawn future investigations alone may decide. But so much at least is firmly established, namely, that the stratigraphic importance of the sequence of marine and continental deposits known to belong between the top of the Richmond and the base of the Clinton in America has been much undervalued. In fact this group seems really to compare favorably in thickness of deposits and in faunal and diastrophic history with most other Paleozoic divisions of similar rank.

No area in America is known in which all of the ages of the Upper Medinan are represented by marine deposits. The only known region containing both the lowest and the highest zones is in southern Illinois and eastern Missouri. This is the typical area of the Alexandrian series of Savage.[1] As finally defined by Savage the "series" embraces the Sexton limestone, hence beds at least as high as the base of the Clinton and as low as the base of the Girardeau limestone which cannot be much younger than the topmost formation of the Richmond group. Savage's term thus covers the time that we have in mind when speaking of the Upper Medinan even though certain parts of the Appalachian rocks of this age, particularly the Whiteoak sandstone, are most probably not represented by deposits in the Mississippi Valley. We propose therefore to adopt the term in the form of Alexandria group for the upper group of the Medinan series. It supplants the previously used term Albion group or stage in the time scale, the discarded name being retained only for the sandy facies that prevails in New York and rather generally in the Appalachian Valley.

[1] Savage, T. E., Am. Jour. Sci., vol. xxv, p. 434, 1908; Am. Jour. Sci., vol. xxviii, p. 516, 1909; Bull. Geol. Soc. Am., vol. xxiv, pp. 351-376, 1914.

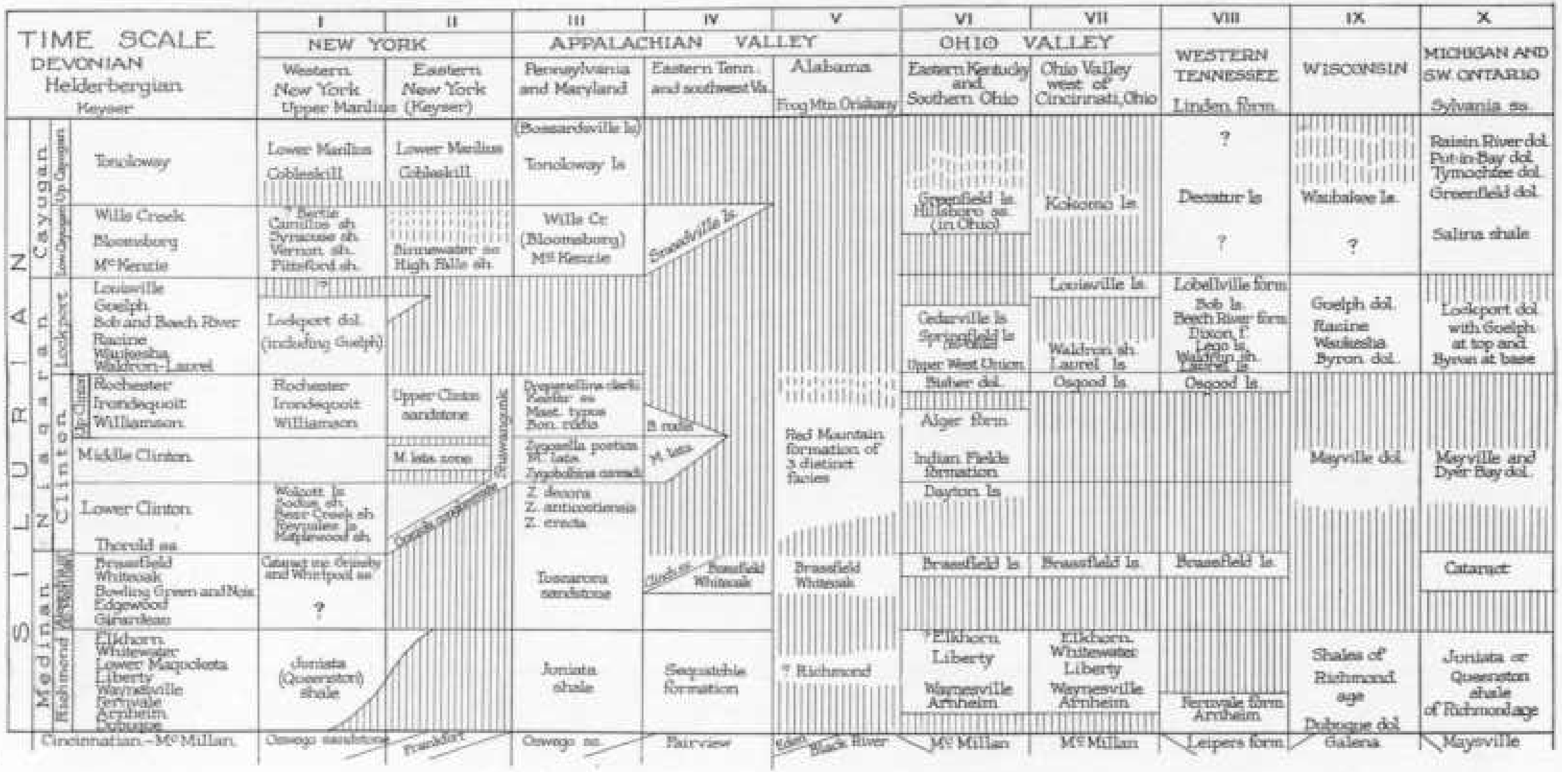

FIG. 3.—CORRELATION CHART OF SILURIAN FORMATIONS.

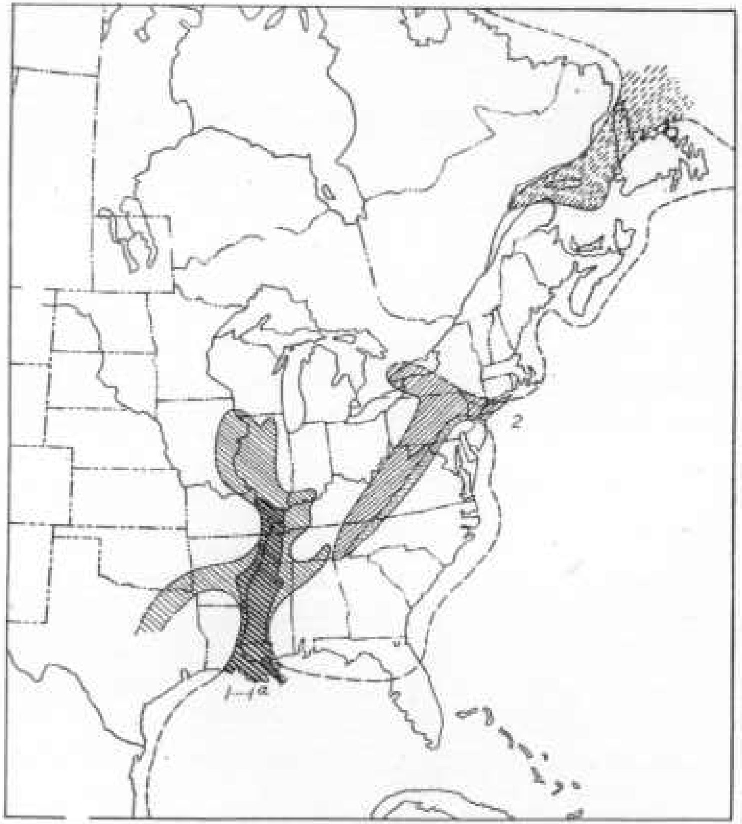

FIG. 4.—EARLY UPPER MEDINAN OR ALEXANDRIA STAGES.

1. Invasion from the south, based on and including only the Girardeau limestone of southern Illinois and southeastern Missouri.
1a. Later invasion from the south, based on the known and probable distribution of deposits containing the Atrypa-praemarginalis fauna—the Edgewood formation particularly.
2. Atlantic invasions and beach deposits—Lower Albion, Whiteoak, Tuscarora, and Clinch sandstones.

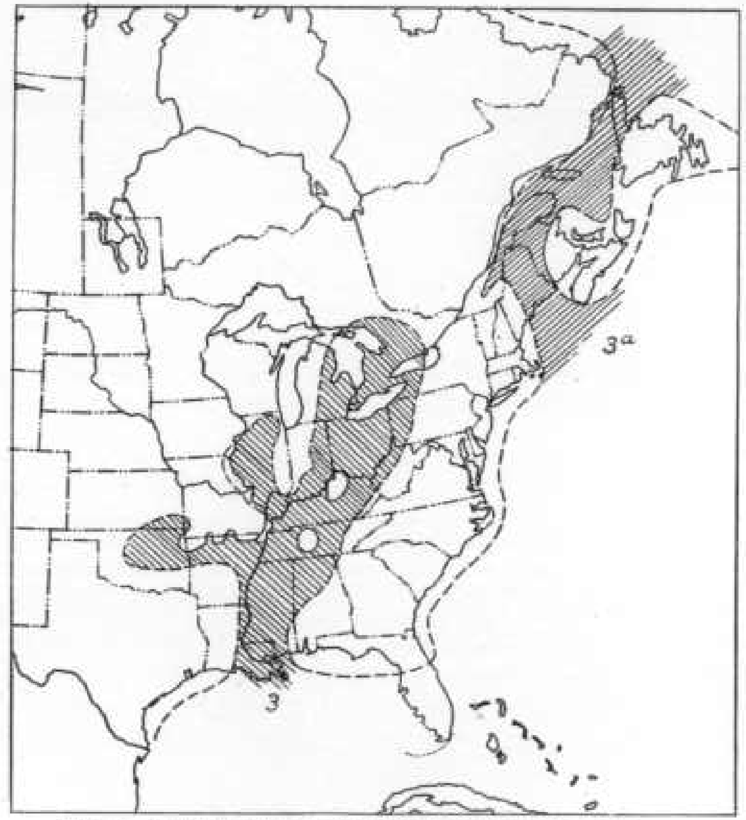

FIG. 5.—LATER UPPER MEDINAN OR ALEXANDRIA STAGES.

3. The Brassfield invasion from the south, based on the distribution of the Brassfield and part of the Cataract (Ontario) faunas.
3a. Atlantic invasion of somewhat earlier or later date, based mainly on the fauna of the Becsee River formation on Anticosti Island.

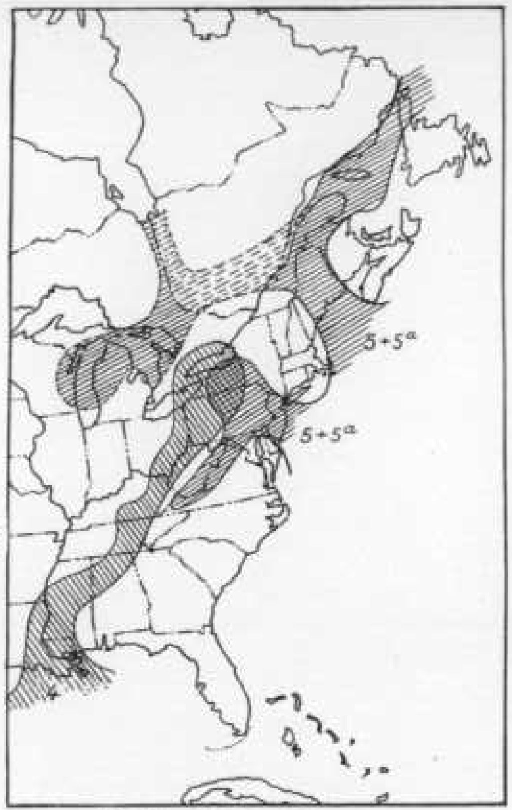

FIG. 6.—EARLY CLINTON STAGES.

4. Invasion from the south, based on the distribution of the Bryozoa and the *Pentamerus oblongus* of the "Reynales" limestone of New York and beds of supposedly corresponding age in Alabama.
5, 5a. Succeeding invasions from the Atlantic side based mainly on the distribution of the *Zygobolba anticostiensis* and *Z. decora* faunas in Anticosti (Gun River and Jupiter River formations), New York (Bear Creek and Sodus shales); and in Lower Clinton deposits in Pennsylvania, Maryland, and Virginia. The Mayville-Dyer Bay dolomite of Wisconsin, Michigan, and Ontario probably represents an independent stage between the *Zygobolba decora* and *Mastigobolbina lata* zones.

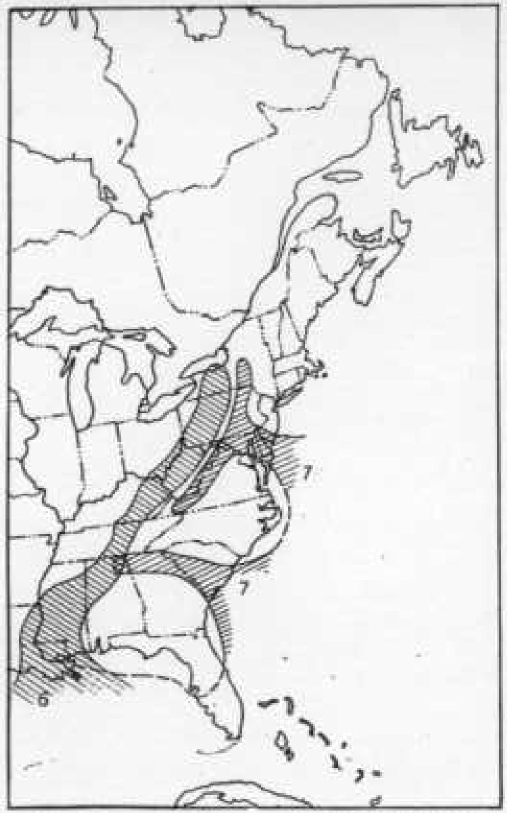

FIG. 7.—LATE LOWER CLINTON AND MIDDLE CLINTON STAGES.

6. Invasion from the south, based on the distribution of the Bryozoa and the second appearance of *Pentamerus oblongus* in the Wolcott limestone of New York and in sandstones of similar age in Alabama.
7. Middle Clinton invasions from the Atlantic side, based on the distribution of the *Mastigobolbina lata* fauna The Mayville-Dyer Bay dolomite of the Great Lakes region included in Fig. 6 may be of this stage.

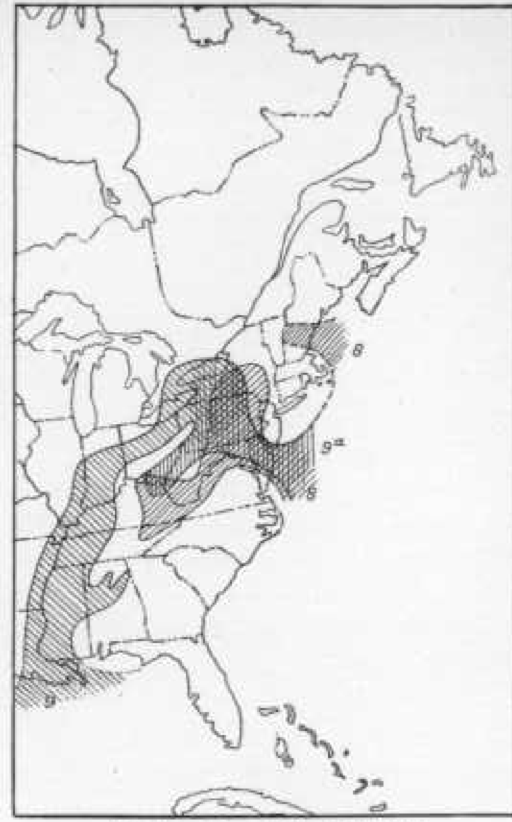

FIG. 8.—LATE CLINTON STAGES.

8. Atlantic invasion, based on the distribution of the *Mastigobolbina typus* fauna in New Hampshire, New York, Pennsylvania, Maryland, West Virginia, Virginia, Kentucky, and Ohio.
9. Southern invasion, based on the distribution of the faunas of the Osgood limestone in the Ohio Valley; and the Irondequoit limestone and Rochester shale in western New York and southern Ontario.
9a. Atlantic invasion of Rochester time based on the distribution of the *Drepanellina clarki* fauna in Pennsylvania, Maryland, and southern Ohio (in Bisher dolomite).

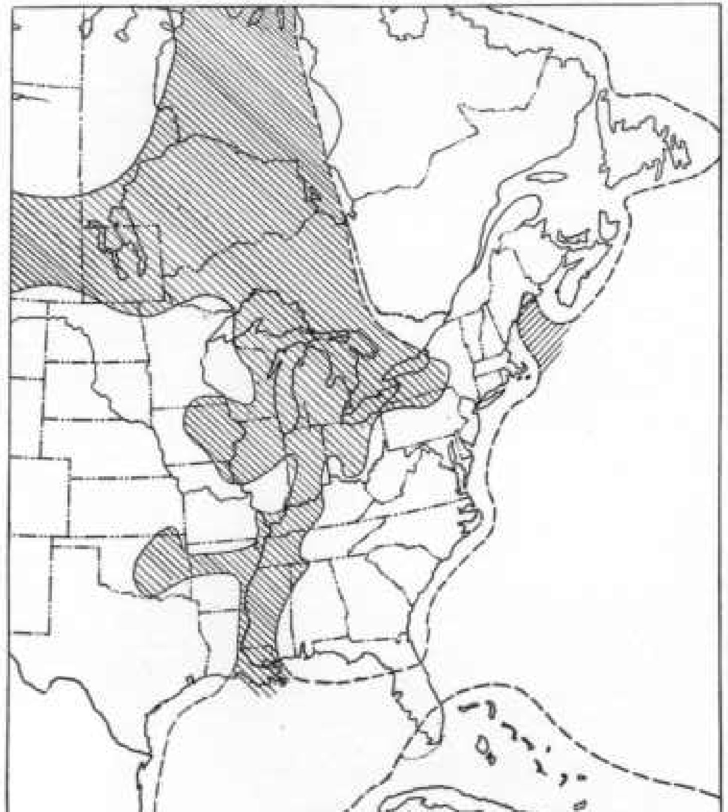

FIG. 9.—UPPER NIAGARAN OR LOCKPORT STAGES.

Composite map of Lockport seas, Laurel to Guelph and Louisville ages, comprising at least five or six distinct, alternating and in part inwardly overlapping northern and southern marine invasions and withdrawals. No deposits of this time in the Appalachian Valley.

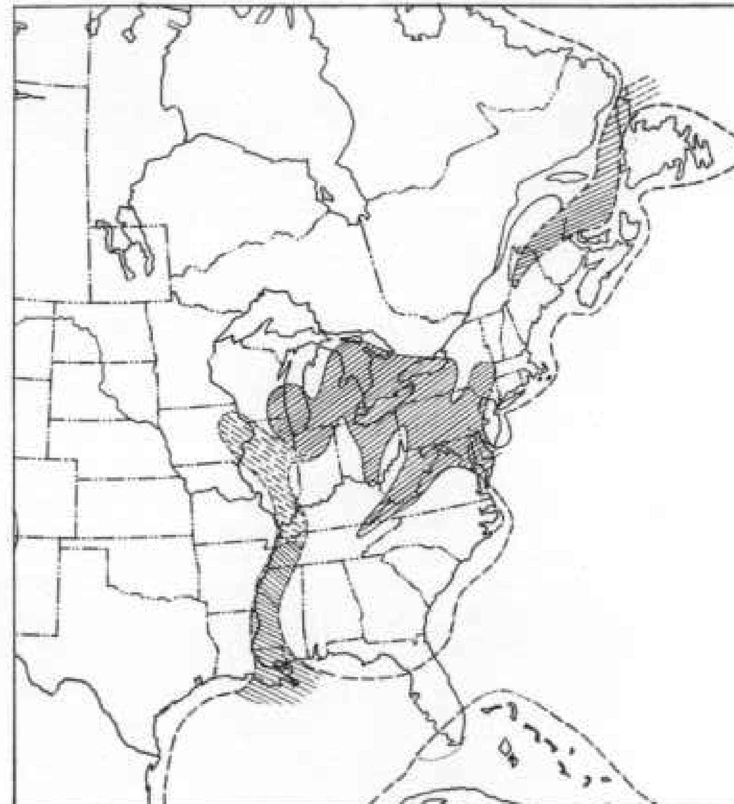

FIG. 10.—CAYUGAN STAGES.

Composite map of Cayugan seas. These invaded mainly from the Atlantic side. The map is based on the distribution of the McKenzie, Wills Creek and Tonoloway limestones in Pennsylvania, Maryland, and West Virginia; the Pittsford shale to the Manlius limestone in New York; the Sneedville (Hancock) limestone in east Tennessee; the Waubakee limestone in Wisconsin; the Greenfield and Bass Island group in Ohio; the Decatur limestone in west Tennessee; and the Gower stage in Iowa.

PALEOZOIC OSTRACODA: THEIR MORPHOLOGY, CLASSIFICATION AND OCCURRENCE[1]

BY

EDWARD O. ULRICH AND R. S. BASSLER

General Morphology

The minute bivalved crustacea known as Ostracoda exist in countless numbers in both fresh and marine waters. Just as to-day, so in the past they were exceedingly prolific, certain rock strata being composed almost entirely of their shells and separated valves. The fossil forms moreover are very constant in the lobing, surface ornamentation, and other features of their shells, so that they have become most useful to the few who know them in identifying stratigraphic horizons. In order to increase the number of students of these organisms and thus to widen their application in stratigraphy, it was thought well to prepare the following account including their anatomical and shell structure. This seemed particularly appropriate at this time because of the fact that the greater part of the Silurian faunas of Maryland consists of ostracoda.

ANATOMICAL FEATURES

The ostracoda are small, generally minute crustacea with the entire body enclosed in a horny or calcareous carapace, the right and left sides of which are separate and articulated along the dorsal edge so as to form a bivalved shell. The body is indistinctly segmented and has seven pairs of appendages of which the first two are antennæ, which, like the others, are also adapted for creeping and swimming. These appendages together

[1] Published by permission of the Director of the U. S. Geological Survey and the Secretary of the Smithsonian Institution.

with the caudal extremity of the abdomen are protruded along the ventral margin of the carapace when the valves are opened.

Behind the first two pairs of appendages (antennules and antennæ) is a pair of mandibles, followed by two pairs of maxillæ and finally two pairs of slender legs. The abdomen is short and rudimentary and its extremity may consist of a single spinous plate or may be bifurcated. The details of the anatomy of the animal are shown in the accompanying text figure. With a single exception the fossil species preserve only the carapace valves (see Fig. 11-1) so that the anatomy of the animal is known almost entirely from living species.

A small median eye and two large lateral eyes are commonly developed, the position of the latter being indicated on the exterior of the valves of certain fossil species by a small "eye tubercle" or ocular spot. A distinct heart is not developed. Respiration occurs through a number of respiratory plates fastened to the mouth parts which by their motion keep up a stream of fresh water pouring between the valves. The alimentary and generative organs are generally well developed. Small animals and decaying vegetable matter form their food for the most part.

SHELL CHARACTERS

The valves are closed by a subcentral adductor muscle, the attachment of which is marked on their inner sides by a tubercle, pit, or a number of small spots. The shell is compact in structure, commonly from 0.5 mm. to 4 mm. in length, although in certain doubtful Paleozoic forms (Leperditiidæ) sometimes exceeding 25 mm. The outer surface may be smooth and glossy, or granulose, pitted, reticulose, striate, hirsute, or otherwise marked, the effect being often quite ornamental. The two valves may be of equal size (Primitiidæ) or more or less unequal with either the right or left valve overlapping at the ventral border only (*Leperditia*) or at the dorsal border as well (*Bairdia*), or in some cases overlapping all round (*Cytherella*).

Among the fossil forms, particularly those of Paleozoic ages, the valves are commonly lobed or sulcate or nodose, and variations in the number, position and relation of these surface characters are regarded as important

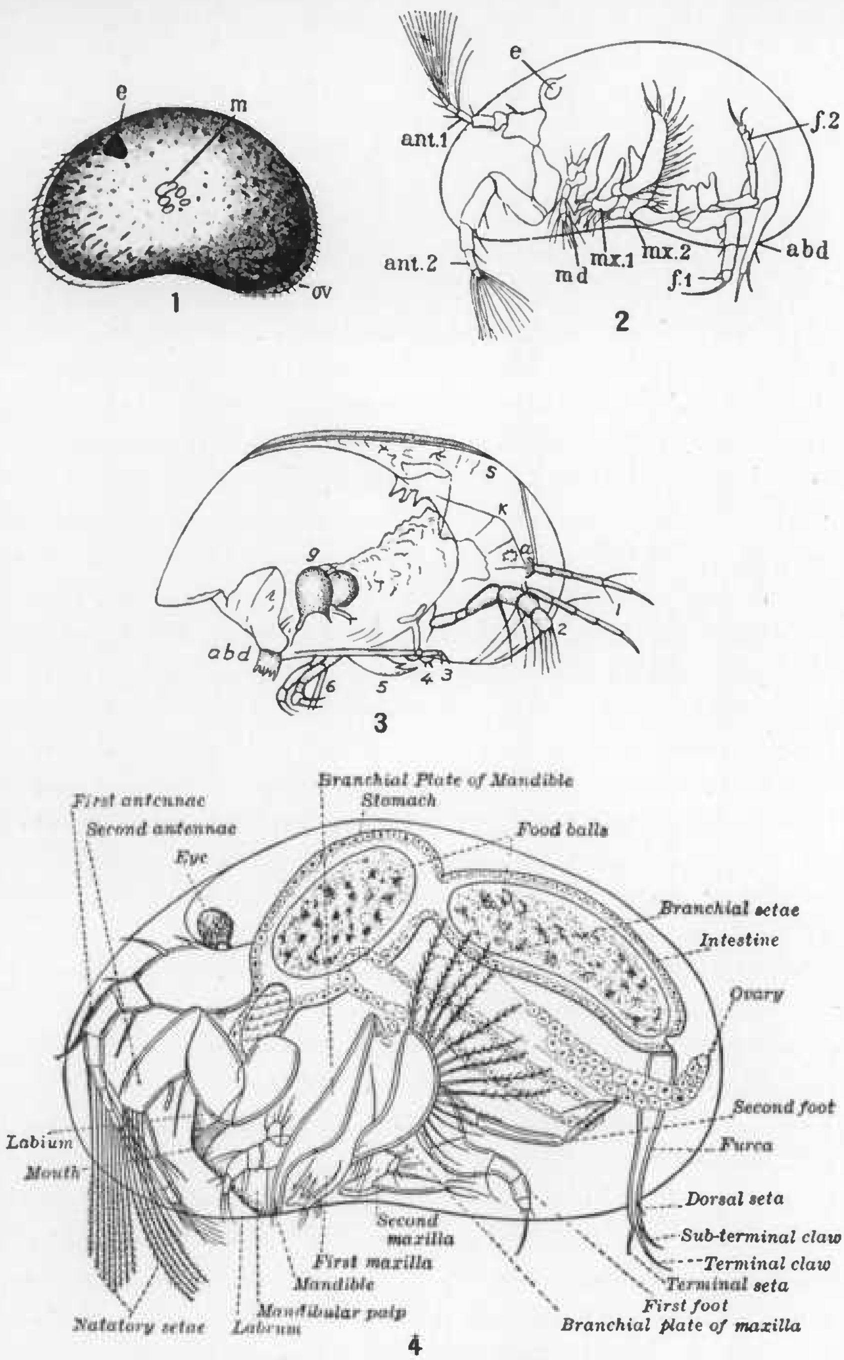

FIG. 11.—ANATOMY OF THE OSTRACODA.

1. Left side of the translucent shell of a recent species of *Cypris*, magnified, showing eye spot (e), the position of the ovary (ov) and adductor muscle scars (m).
2. Sketch showing anatomy of the same species: median eye (e), abdomen (abd), antennule (ant. 1), antenna (ant. 2), thoracic feet (f. 1, f. 2), maxillæ (mx. 1, mx. 2), mandible (md) (figs. 1, 2, after Gerstaeker).
3. Fossil ostracod (*Paleocypris edwardsi*, Carboniferous of France) preserving the internal structures which are silicified. Shell (s), incomplete behind, abdomen (abd), genital regions (g), antennulæ (1), antenna (2), mandible (3), premaxillæ (4), maxillæ (5), thoracic appendages (6) (after Brongniart).
4. Detailed anatomy of the recent species *Cypris virens* Jurine (after Vavra). The ends of the adductor muscle are seen in the middle of the figure.

by the paleontologist in segregating the seemingly endless number of species into genera and families. The student of the living depends for his taxonomic criteria almost entirely upon the characters of the soft parts of the animals which are almost never preserved in the fossil state. However, as the lobing of the valves in the fossil forms is developed in similar manner and often even more distinctly on their inner sides than on their exterior surfaces it is evident that the varied lobing and sulcation of the valves and the presence of large protuberances or nodes on the exterior can be nothing else but external manifestations of and conforming to internal anatomical features of the animals themselves. Though it may be, as a rule, impossible to interpret the meaning of these shell characters we may nevertheless appreciate and establish their respective values as taxonomic criteria by noting the relative persistence of each particular feature both severally and in combination with other characters. If the same peculiarity is recognized in a number of otherwise similar yet clearly distinguishable species then we may reasonably infer that it represents some anatomical character of sufficient importance to the animal to require its maintenance and continued development through one or more diverging or parallel lines of genetically allied species. Obviously, too, the relative importance of any single character or any combination of characters is in proportion to its persistence in nature. It follows also that the taxonomic importance of a character is determined not so much by extravagance in development as by its persistence.

Regarding the lobing of the carapace, particularly as developed in Beyrichiidæ and Zygobolbidæ, it may very well be explained as an external manifestation of the segmentation of the animal itself. In the living species the body usually is indistinctly segmented and the abdomen short. But it does not follow that the segmentation in the Paleozoic Beyrichiacea was similarly indistinct or that their abdomen was equally short. On the contrary, if the Ostracoda were evolved, as seems most probable, out of preceding Branchiopoda the chances strongly favor the assumption that in the Beyrichiacea the segmentation of the body was more distinct and the abdomen longer than in recent Ostracoda. At any rate the definite information concerning these parts in the Cambrian Branchiopoda which we owe to the researches of Walcott[1] leaves no doubt regarding the clearness and generally larger number of their segments.

The exceeding persistence of the posterior lobe and the fact that this lobe often is prolonged by curving anteriorly across more or less of the ventral slope of the valves suggests that it received the infolded thorax and abdomen when the animal retreated to and closed the valves of its shell. If this suggestion is well founded, then we get some idea of the length of the thorax and abdomen from the degree in which the posterior lobe is prolonged along the ventral side. They would have been long, for instance, in such Ordovician genera as *Drepanella, Ceratopsis* and *Tetradella,* and relatively short in *Beyrichia* and most of the Zygobolbidæ. This suggestion also gives a plausible explanation of the purpose of the otherwise unexplained submarginal ridge which so often, notably in *Paræchmina* and *Drepanella* dies out on the anterior slope.

Under the law of determining values by relative persistence certain other features of the shell that are less obviously connected with anatomical characters of the animals and which occur mainly among Paleozoic representatives of the class must also be counted as important. We refer here particularly to the false borders which commonly project beyond and hide the true contact edges of the valves. Sometimes, as in the Eurychilininæ, these form frill-like extensions of such great width that it seems impossible that the appendages of the animal could have been protruded beyond their outer edges. Often these frills are developed best or only on the posterior half or two-thirds of the valves and sometimes the concave area beneath them is broken up into loculi. Their purpose is doubtful, the only plausible explanation being that they served for the temporary lodgment and protection of broods of young.

As only the shell of the Ostracoda is found fossil, and since the major classification, as determined from living forms, is based principally upon characters presented by the appendages, the relations of fossil to recent forms is necessarily more or less uncertain and in many instances probably must remain undeterminable.

[1] Walcott, C. D., Middle Cambrian Branchiopoda, Malacostraca, Trilobita and Merostomata, Smithsonian Miscellaneous Collections, 1912, vol. lvii, no. 6.

Most commonly the outline of the carapace is ovate or reniform, and it is always so when the valves overlap on the dorsal side. In many cases, however, either and rarely both ends may be pointed or drawn out in the form of a beak; and when the dorsum is straight, the ends usually join it angularly, the sharper of the two being the anterior. Although usually convex, the ventral margin is sometimes straight or gently concave. In fossil forms it is sometimes impossible to distinguish between the anterior and posterior extremities of the shell but as a rule the posterior half even though of equal or less height than the anterior is somewhat the thicker or blunter in dorsal views. Frequently in certain Middle Paleozoic genera a brood pouch is developed, thus clearly marking the posterior end. The hinge-line may be straight or arcuate, the hinge itself being generally simple, although among the Cytheridæ hinge teeth and corresponding sockets are often developed. Except in the large Leperditiidæ, which may be Phyllopoda rather than Ostracoda, the exterior of the valves only very rarely gives any definite indication of either the small median or the two large lateral eyes that are found in many of the living species.

REPRODUCTION

The sexes in the ostracoda are distinct but usually in the recent species the shells of both sexes are of the same size and shape. In some, however, for example, *Candona,* the males are larger and of different shape while in the well-known *Cypris* the females are the larger. Both the male and female sexual organs are of rather complex structure and variations in their form are regarded by systematists as valuable specific distinctions. Propagation is both by fertilized eggs and by unfertilized eggs or parthenogenesis. In the latter case a number of parthenogenetic generations may be preceded by a sexual one. Again in some species, even after long search, males have never been discovered. These various methods of propagation, namely, always sexual, temporarily parthenogenetic and always parthenogenetic, have been used as distinctions of generic value.

The eggs are covered with limy shells varying in color with the species from white to orange red and dark green. They are laid in characteristic ways, some singly, others in packets on the leaves of water plants and others again in regular rows. Bottom forms crawl to the roots of water plants and then to the leaves where they deposit their eggs and fasten them with threads, having previously scraped off a suitable place with their antennæ. The eggs have great vitality, for those in samples of dried mud after 30 years' time have been hatched. Indeed one student, G. O. Sars, has described many new species of ostracoda which he raised from the eggs contained in dried mud sent him from distant countries. The eggs hatch into larval forms, nauplii, which differ greatly from the mature stages into which they pass after many moltings.

So far the rocks have revealed no trace of larval forms of Ostracoda. Indeed the possibility that such may yet be found seems quite hopeless when we consider the altogether unusual conditions, referring especially to the suddenness and permanence of their original burial, that would be required to insure the preservation of such delicate and readily decaying organisms. But the fossil forms are not entirely uncommunicative on so important a factor of reproduction as sex discrimination. There is at least one large group of fossil Ostracoda, in fact it is the most important of the Paleozoic representatives of the class, namely, the Beyrichiacea, in which the individuals of species of many genera are separable by most conspicuous differences, into two kinds that can scarcely indicate anything other than fertilized females on the one hand and males and probably also unproductive females, on the other. In its simplest expression, as in the strongly convex carapaces of *Welleria* and *Plethobolbina,* the difference between the shells of the two sexes consists merely of the slightly greater obesity of the post-ventral half of the individuals that we are designating as females. In its most specialized development, as in the relatively emaciated carapaces of *Beyrichia,* the difference is much more conspicuous, the slight swelling of the surface being represented in these by a large semiovate or subglobular pouch which covers most of the post-ventral quarter of each valve. Between these two extremes the many genera in which such differentiation of the sexes is known, the brood pouch as we call it, affords a great variety of intermediate forms. In others again, especially in the genus *Mastigobolbina,* the brood pouch is extremely large and capacious, covering the posterior two-fifths of the valves. In others again, as in *Mesomphalus,* it forms a long sausage-shaped swelling covering most of the ventral slope. Finally, in the genus *Zygosella,* it forms a narrow curved extra lobe or rounded ridge close to and paralleling the posterior edge.

As a rule these pouches communicate directly with the inner cavity of the shell by means of a large opening just within the contact edges of the valves. As a rule, again, though their bases commonly spread to or beyond the outer edge of the border, their greater part lies on the convex part of the valves within the border. However, in a few Ordovician types, notably *Eurychilina ventrosa,* there is a similar swelling with probably related functions, that is entirely confined to the border and which does not connect directly with the inner cavity of the shell. Another peculiar and entirely external development of the pouch occurs in *Primitiopsis* in which it forms a large simple, externally smooth and obscurely off-set, internally concave addition to one end of each valve. What may prove to be a transition from these external cavities toward the usual internally opening pouches is found in the Baltic Ordovician *Chilobolbina dentifera* Bonnema. In this species the inner third of the pouch lies on the ventral slope of the valve proper. Unfortunately it is not known whether it opens on the inner or outer side of the contact edge.

It has been suggested that these pouches are abnormal, in fact, pathological swellings. But it is inconceivable that anything abnormal or of pathological origin could possibly have been developed with the constancy of form and position that pertains to these pouches. One would expect to find more or less of unrelated irregularities in form, size, position, and surface marking in any abnormal structure. On the contrary, comparison of many hundreds of these female examples, amounting in some instances to more than two hundred of the pouched individuals of the same species, has resulted in absolute failure to discover any such irregularities in the development of the pouches. Indeed, no specific feature is more accurately reproduced in the individuals of a particular species than is the particular form of brood pouch which helps in characterizing it.

DISTRIBUTION

Like all other organisms the distribution of the ostracoda is influenced by the conditions under which they must live, but as a class they are perhaps less sensitive to change in environment than most other classes of animals. Direct light accelerates all their life processes so that the free swimming forms are almost indicative of well lighted areas. Again the forms less able to swim spend most of their existence in the slimy debris and ooze of the bottom. Some forms exist indefinitely in waters that have become quite foul, as in sewers, others live in sulphur water and in hot springs. But practically no species are found in pure cold spring water or well water. Such facts suggest that the ostracoda thrive very well under conditions that would be decidedly unfavorable for the existence of most other kinds of invertebrates. They not only could live under conditions that would usually be regarded as unfavorable, but on account of the minuteness and lightness of the shells these were swept along by waves and currents to places where they did not live; all of which tends to enhance their value as guide fossils. Accordingly we find their remains in all kinds of sedimentary rocks, with little difference as to abundance or kind, whether the rock is a sandstone, a shale or a pure limestone.

The recent Ostracoda, including both the fresh water species and the marine forms, are world-wide in distribution. Not only are many of the species properly termed cosmopolitan, but they are also apparently unlimited bathymetrically. To-day we find them swimming at the surface or creeping over the bottom in great colonies, and after the death of the animal their shells are scattered far and wide, both on the land and in the water.

Many of us in our field work have no doubt come across small pools, sometimes a foot or less in diameter, swarming with fresh-water ostracods. In such instances, as evaporation proceeds, the pool will become a fairly solid mass of ostracods, and finally, when the water has disappeared entirely, their dead shells will be scattered by the winds as dust, sometimes to considerable distances. Fresh-water Ostracoda are therefore a factor in continental deposits. In the sea a similar wide dispersal, independent of the animal's life history, depends on the waves and currents, which bear the dead shells far from their habitat in life and scatter them broadcast, so that their final resting place may be in the shallow littoral deposits.

Most of the modern as well as ancient Ostracoda are of microscopic size, and for this reason, even though in individual development they probably exceed almost every other class, they must always remain an inconspicuous element of any fauna. Another and more serious difficulty, especially in the study of the fossil forms, lies in the simplicity of shell structure found in some of the families. Among the recent faunules, species and even genera, particularly of the smooth shelled families, are established on anatomical characters, the shell being practically disregarded. It is a fact that several distinct genera have shells with essentially the same outline and surface characters. The difficulty, if not impossibility, of distinguishing such genera among fossil forms is obvious. For example, *Bythocypris cylindrica,* an abundant fossil in practically all of the Middle and Upper Ordovician formations is closely differentiated from associated Cypridæ, yet the name possibly covers shells of a number of distinct species that were readily distinguishable by anatomical peculiarities. In fact so far as one can see, its shell is practically duplicated in outline and general structure by those of living species belonging to widely separated genera. For stratigraphic purposes, therefore, most of the Cypridæ have little value. However, this may be said only of these relatively characterless types.

The case is quite different with the much more characteristic Beyrichiacea, which comprise the bulk of the Paleozoic Ostracoda, and the Cytheracea which are so common in the Mesozoic and Cenozoic formations and in the seas of to-day. Nearly all of these are separable into finely drawn and precisely identifiable species and varieties of relatively short duration. When we add to these qualities the already mentioned facts concerning their ready adaptability to all kinds of environment and their exceeding abundance and wide geographic distribution the high value of these remains as guide fossils in stratigraphy is clearly apparent. Moreover because of their small size this value is particularly manifest in determining the age of beds passed through in drilling deep wells.

METHODS OF STUDY

As the fossil ostracoda occur in all kinds of rock ranging from unconsolidated sands or marls to dense hard limestone or sandstone, it is evident that the preparation of specimens for study varies with the matrix. Most of the Mesozoic and Cenozoic ostracoda occur in unconsolidated material from which, after washing away the clay, the specimens

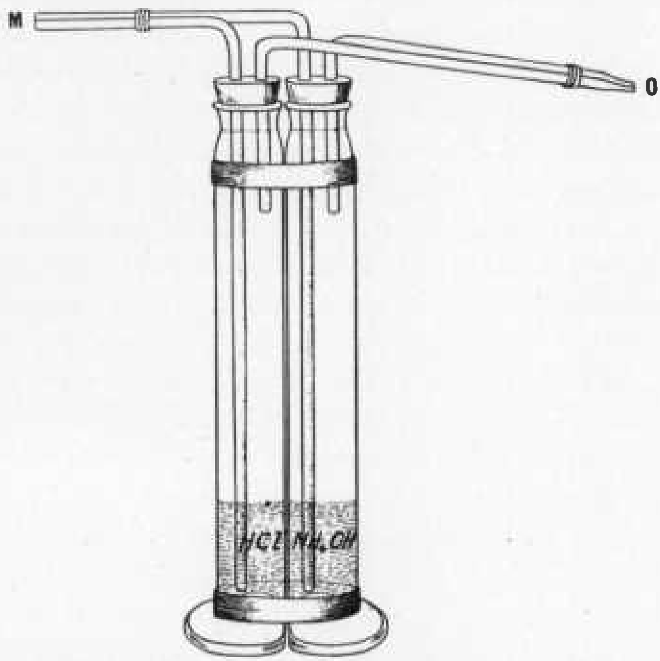

FIG. 12.—APPARATUS FOR WHITENING OBJECTS FOR STUDY.

Blowing through the mouthpiece (M) the fumes of hydrochloric acid (HCl) and ammonia (NH_4OH) unite at O and deposit a thin coating of white ammonium chloride upon the object held a few inches from this point.

are easily picked under a hand lens or binocular microscope. Samples of such rocks supposed to contain ostracoda should be allowed to soak in water for some hours. The material may then be agitated and the muddy water poured away. Continuing this process until the agitated water no longer becomes muddy the residual mass is set aside to dry. The debris when dried is then ready for assorting although passing it through several sieves of different mesh greatly facilitates the assorting of the contained fossils. The ostracoda in such debris may be concentrated at the surface to a considerable extent by gently tapping the containing vessel, because, being light and boat shaped, they have a tendency to rise to the surface.

The frequent occurrence in Paleozoic rocks of a thin seam of shale on top of a fossiliferous limestone bed affords an opportunity to secure the ostracoda as well as other fossils in greater abundance by washing quantities of the shale in the same manner as above described.

For species occurring in solid limestone the procedure is quite different. Specimens in hard clayey limestone may frequently be released from the matrix by the application of caustic potash in stick form and carefully washing and sifting the resulting muddy debris. Crystalline limestones preserve the ostracoda best of all, but here the preparation is more difficult because the rock must be broken to expose the specimen and the edges of the valves as well as the surface features must be carefully uncovered with a fine lithographic pick or needle. As the shell of the ostracoda is frequently very smooth or glossy, the specimens often pop out of the limestone when the latter is broken into small pieces. Such rock should be inclosed in a sack and pounded into comparatively small fragments with a wooden mallet. The resulting debris may then be washed and sifted for ostracoda as before.

In limestone in which upon weathering the fossils tend to become silicified, the ostracoda as well as other organisms may be freed by treatment with dilute hydrochloric acid and then picked out of the resulting debris.

Frequently, as in the sandstones and sandy shales of the Clinton group, the shell has been dissolved away, leaving only the interior and exterior mold of it. These molds often preserve details of structure and surface ornamentation that are but seldom so well shown on specimens in limestone that have been exposed by natural weathering. Very satisfactory replicas of either surface of the valve are procured by means of impressions made of guttapercha or some other plastic material.

The simplest way of preserving ostracoda that have been freed from the matrix is to mount them upon cardboard slips of sufficient size to receive the data concerning them but still small enough to be contained in glass vials.

The shells of many fossil ostracoda are of such a color that the details of the surface structure upon which the criteria for determination depend, are difficult to see and interpret. This is particularly true in the Silurian forms such as the numerous species of *Klœdenellidæ* whose black shells occur by the millions in certain strata. Again the glasslike shells of most of the recent and many fossil species are most difficult to study for the same reason. In all of these cases the surface outlines and markings are brought out in great clearness and perfection by whitening the specimens with a film of ammonium chloride. A simple apparatus for this purpose is shown in text Fig. 12. The hydrochloric acid and ammonia used should be of great strength for the best results, and small quantities only should be employed so that the bottles can be emptied and dried frequently as the reagents not only become weakened by the absorption of water but lose their strength in a day or two of use. The sublimate can be deposited upon the object in such a uniform thin film, varying according to its thickness from light blue to ivory white, that all the details of structure are reproduced perfectly and can be viewed even under the microscope without exhibiting any crystalline structure of the ammonium chloride. The white film can be removed by simply breathing upon the object so coated.

Orientation of the Valves

In the study of fossil Ostracoda the question as to which of the two ends of the carapace is the anterior is the most troublesome and the one on which students have differed most. Jones and other authors commonly followed the rule of regarding the thicker or blunter end as the posterior. In our experience Jones' rule proved much oftener true to nature than misleading. But there were too many exceptions so that it becomes necessary to seek other criteria which might prove less uncertain. Such other criteria were pointed out and discussed by us in an earlier revision of the Beyrichiidæ.[1] Thorough study of these together with all other

[1] Ulrich, E. O., and Bassler, R. S., Proc. U. S. Nat. Mus., vol. xxxv, p. 280, 1908.

Ostracoda likely to throw any light on this vexing question resulted in the discovery of four other more or less helpful similarly trending and taken together probably decisive means of solving it. These criteria con-

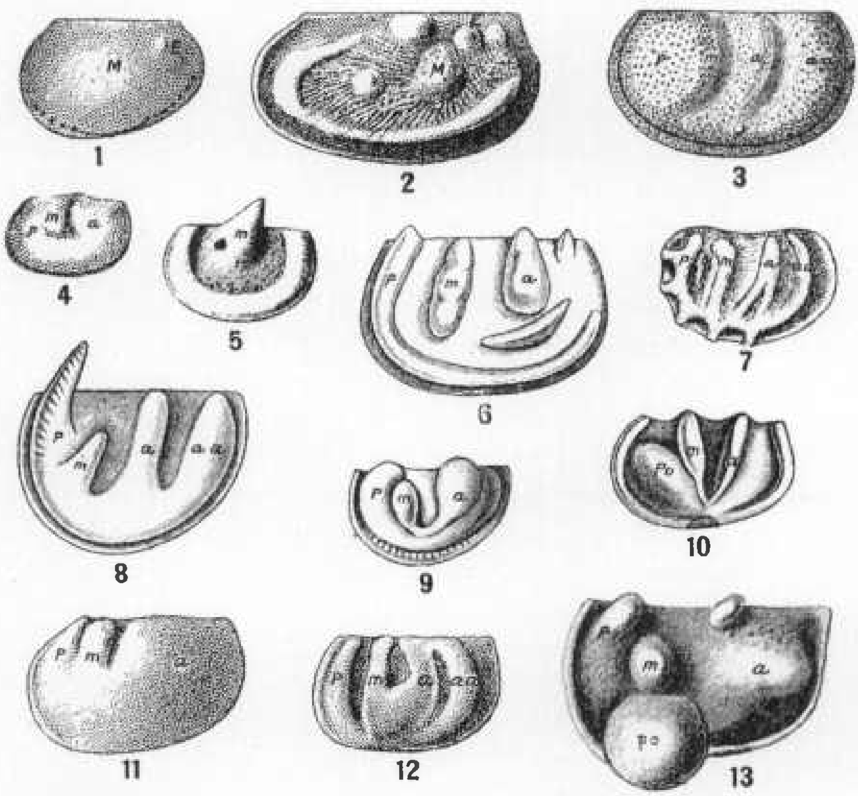

FIG. 12A.—ILLUSTRATING SHELL CHARACTERS OF PALEOZOIC OSTRACODA.

1, 2. Valves of *Leperditia* (1) and *Saffordella* (2) showing muscle spot (M) and eye spot (E).
3-6. Valves of *Ctenobolbina* (3), *Primitia* (4), *Paræchmina* (5) and *Drepanella* (6) exhibiting the position of the anterior (a) median (m) and posterior (p) lobes.
7, 8. Two genera, *Tetradella* (7) and *Ceratopsis* (8) in which the anterior lobe is divided (a, aa).
9. Lobation in typical *Beyrichia*.
10. Right valve of female in *Zygobolba* showing brood pouch (po).
11, 12. *Klœdenella* (11) with lobation little developed and *Dizygopleura* (12), of the *Klœdenellidæ* in which it reaches an extreme.
13. A Silurian species of *Beyrichia* with nodose development of lobes.

cerned (1) the relative width, position and direction of the median furrow or sulcus which was found to be wider than either the anterior or the posterior sulcus, to lie almost always more or less behind the mid-length of the valves and which when prolonged ventrally was found to curve more or less backward; (2) the correlation and identification of the median and posterior lobes, both of which lie behind the median sulcus and usually are distinctly separated by the posterior sulcus though occasionally completely confluent, as in *Ctenobolbina ciliata;* (3) the outline of the valves, particularly in straight-hinged forms, which commonly are more or less oblique and widest behind with a backward swing from the hinge, and which suggests a parallelogram rather than an oblong; (4) the location of the brood pouch which obviously should be associated with the posterior half of the carapace and in fact always lies at least for its greater part, behind the anterior lobe. Another criterion that often is useful rests on the previously suggested purpose of the ventral prolongation of the posterior lobe as a lodging space for the incurved abdomen when the animal retreated to the inside of the shell and closed its valves. If this suggestion is based on fact then it follows obviously that the more persistent end of the submarginal ridge must be posterior and the other end, which may die out at any point between the middle of the ventral side and the antero-dorsal angle, must be directed toward the front. The various features here discussed are illustrated on the accompanying text figure (Fig. 12a).

Criteria in Classifying Fossil Ostracoda

The criteria employed in the study and separation of species of fossil ostracoda refer entirely to the shell. They may be classified under the following headings.

1. Differences in size, outline, convexity of valves and location of greatest thickness. Such distinctions vary greatly in value being used in discriminating varieties, species, genera and families, the values depending on relative persistence of occurrence.

2. Nature of hinge. It is essential to observe whether the hinge is straight, the two valves fitting evenly, or whether articulation is by overlap of the more or less rounded dorsal edge of one or the other.

3. Modification of the hinge. Modifications such as internal denticles (Cytheridæ) or external interlocking processes (Klœdenelliidæ) are important and should be carefully noted.

4. Overlap of edges. Studying entire carapaces, it should be observed whether the valves are unequal or equal and when unequal which valve overlaps the other and whether the overlap is mainly or wholly confined to the dorsal edge which is rather rare, to the ventral side a more common occurrence, or takes in the entire circumference, one valve being set into the other. Such modifications are usually considered of generic and family importance.

5. Surface characters of valves. Here it should be observed whether the valves are simple, smoothly convex, or develop terminal spines or a border at the contact edge or a false border which overhangs the contact edges. The false border may be simple or developed into a broad, radially lined frill. This frill may be a simple flat plate or may be convexly bowed to form a marginal chamber beneath it, or it may be modified in various other ways.

6. Lobation of valves. Good generic characters are found in the lobation of the valve. In the simplest forms there is a small subcentral depression or pit (probably always indicating the attachment of the adductor muscles) which may be prolonged slit-like as a sulcus to the dorsal edge or extended toward the ventral margin. In other forms there is a node on either side of the pit which may be modified into long lobes. The lobe posterior to the median sulcus is designated the median lobe. This may be defined on its posterior side by another sulcus thus separating a posterior lobe. Anterior to the median sulcus is the anterior lobe which is often again divided by another sulcus. These three lobes are present in one form or another in practically all of the Beyrichiacea and variations in their development always afford good specific characters and often distinguish genera. Any or all these lobes may be prolonged into spines dorsally. The confluence of the lobes or their immersion in the general surface by an increase in convexity of the valves or their breaking up into smaller nodes or ridges are all to be noted and are of varying importance. Excellent examples of these features occur in the Klœdenellidæ and Beyrichiidæ.[1]

[1] Ulrich, E. O., and Bassler, R. S., Revision of the Beyrichiidae, Proc. U. S. Nat. Mus., vol. xxxv, pp. 277-340, 1908.

7. Surface ornamentation. As a rule reticulation and other forms of surface ornament of the valves are not of generic importance but are always useful in specific determinations. Crest-like ribs traversing the surface irrespective of the lobes, or crowning them, as in *Steusloffia, Mastigobolbina* and *Strepula,* are commonly regarded as of higher value.

8. Sex characters. The presence or absence of a separate pouch-like swelling regarded as a brood chamber for the development and protection of the larvæ in many of the Beyrichiacea is regarded as a generic character.

STRATIGRAPHIC OCCURRENCE, ORIGIN AND CENTERS OF DEVELOPMENT AND DISTRIBUTION

Many species supposed to be Ostracoda have been described from Cambrian rocks, but recent unpublished studies show that all of these are bivalved Branchiopoda and possibly true Conchostraca. The oldest of the forms still retained in the Ostracoda are members of the family Leperditiidæ which also may have to be removed to some other order. However, as the Leperditiidæ are the only known group of Eucrustacea from which the true Ostracoda might have been derived the most logical course provisionally is to leave them as hitherto, namely, the first family of the superorder Ostracoda.

Accordingly, beginning with the Leperditiidæ the Ostracoda make their first appearance in the Middle to Upper Canadian rocks of America in which apparently nearly typical species of *Isochilina* have been found in the south central states of Tennessee, Missouri, Arkansas and Oklahoma, and in the Champlain Valley of the northern Appalachian region. The faunas with which these occur, likewise the regions in which they have been found, suggest that they originated in the south and middle Atlantic and invaded the American continental seas of the time from those directions. So far none have been found in Pacific or European deposits of Canadian age. During the Ordovician the Leperditiidæ increased in importance and extended their range in east, north and west directions while holding their own in the south. But following the Trenton they seem to have become extinct in the southern waters, no Leperditiidæ being known in any later Ordovician or Silurian fauna concerning which anything like certainty prevails regarding its southern origin. In the northern Atlantic and Polar regions, on the contrary, the genus *Leperditia* attained its maximum development both as to size and abundance of individuals and species. This greatest development preceded only a relatively short time the final extinction of the family in the early Devonian.

The oldest of the smaller true Ostracoda are found in the lower Ordovician rocks of the Chazyan series. They include Aparchitidæ—which probably were directly derived out of Leperditiidæ and attained their maximum development in the Ordovician—and a great number of primitive Beyrichiacea. The Aparchitidæ are most abundant in the Stones River and Black River faunas that invaded from the south, are entirely absent in the succeeding southern Ordovician and Silurian, but reappear in modest numbers in the Onondaga Devonian and certain late Mississippian faunas. The family is not represented in the Chazyan faunas of the middle and northern Appalachians, but in the late Black River its most typical representatives had spread to the Polar seas from which it invaded to Minnesota with the Decorah fauna. During the Silurian the Aparchitidæ seem to have been confined to the north Atlantic, leaving a few representatives in the Appalachian and St. Lawrence faunas of that time and more of them in the Wenlock of England and the Gotlandian of Sweden.

The Beyrichiacea are already strongly represented in the early Chazyan deposits, especially in those of the southern Appalachian region and in the Simpson formation of central Oklahoma, by various types of the relatively simple Primitiidæ and Eurychilininæ. Though probably originating in the south Atlantic these soon attained cosmopolitan distribution, being found in lower and middle Ordovician deposits in Nevada, the Mississippi Valley, the Appalachian region from Alabama to Canada, Great Britain, the Baltic provinces and other regions. Some of the later more specialized genera of the family apparently were of relatively short duration and limited in geographic distribution. For instance, the late Ordovician *Jonesella* seems to have been confined to southern faunas of Eden age; *Dicranella* and *Dilobella* to northern invasions of late Black River and Trenton ages; and *Primitiopsis* to the Silurian of the Baltic region. The extraordinary horned genus *Aechmina,* although first described from Silurian species found in England and the Island of Gotland, began much earlier in America where we find an incipient species in the lower Ordovician, a typical representative in the upper Ordovician, and at least one Silurian and one early Devonian species. The closely related *Paræchmina,* on the contrary, though also a middle Atlantic type is unknown in Europe, but widely distributed and represented by many species in eastern America.

The Beyrichiidæ also seem to have originated in the south during the Ordovician though they delayed their advent to the middle Ordovician. The Ordovician genera of the family differ from their Silurian descendants in having the anterior lobe divided, making them quadrilobate instead of trilobate, also in lacking the brood pouch which generally distinguishes the female in the Silurian genera. It is interesting to note that in the decadence of the family, which became largely extinct in the Devonian and entirely so in the Mississippian, at least one of the genera (*Hollina*) reverts to the primitive quadrilobate stage. Others are so much like middle Ordovician species of *Ctenobolbina* and *Ceratopsis* that one is left in doubt whether they should be regarded as survivors or as reversionary new developments. Ordovician Beyrichiidæ occur somewhat sparingly in northwestern Europe but the more prominent of the American genera, particularly those associated with distinctively southern faunas, are unknown there. Directly the opposite is true of the Silurian Beyrichiidæ. These are exceedingly abundant and varied in structure in northwestern Europe but exceedingly rare in American Silurian faunas that invaded from the south. Even more unexpected is the fact that they are wanting also in the northern Silurian faunas. But all ostracoda are practically wanting in the Silurian of interior America except in those faunas that are definitely known to have invaded from the Atlantic side.

The Silurian Atlantic invasions gave us the exceedingly prolific ostracod faunas of the Appalachian region which are described in this volume. So far as known it was only during the closing stages of the Clinton that these Atlantic invasions extended westward into interior areas that commonly were subjected to alternating northern and southern invasions.

The most important if not the only well-established instances of such westward extensions are (1) the commingling of distinctively Atlantic ostracods like *Dizygopleura* and *Paræchmina* with normally southern types of bryozoa and other classes of fossils in the Rochester shale of western New York; (2) the extension of the fauna of the *Mastigobolbina typus* zone of the upper Clinton in uncontaminated condition from southwestern Virginia across Kentucky into southern Ohio where it is confined to a definitely limited formation known as the Alger formation; and (3) the similar extension of the *Drepanellina clarki* fauna at the top of the Clinton to the same part of southern Ohio. As the concerned faunal zone is wanting in Virginia, the latter invasion of Ohio must have followed a different path. Evidently it turned more directly westward from Pennsylvania or Maryland. Another interesting feature concerning it is the fact that whereas the *Drepanellina* fauna occurs in a shale formation with few to many thin layers of pure limestone in Maryland and Pennsylvania, in Ohio, on the contrary, it is found in a slightly cherty dolomite known as the Bisher member of the West Union formation.

Like the typical Silurian Beyrichiidæ so also the Zygobolbidæ, the Kirkbyidæ and the Klœdenellidæ of the same period, are almost entirely confined to faunas that must have invaded America from the north middle Atlantic. Many of the genera of these families are suggested or represented by primitive types in the southern lower and middle Ordovician faunas but only *Drepanella*, which is prominently considered as a probable ancestor of the Zygobolbidæ, appears in any post-Ordovician southern fauna. After a long absence from southern faunas, lasting through the upper Black River, Trenton, Eden and Maysville ages, this genus reappears with a single well-marked species in the lower Richmond of Ohio. The same species occurs also in the lower part of the red Juniata and Sequatchie formations in southwestern Virginia and Tennessee, and in red beds of the age of the Queenston shale near Toronto, Canada. So far as known there is no reason to doubt the essential contemporaneity of these widely separated occurrences.

The Cypridacea began in the lower or middle Ordovician and have lived on to the present. They seem also to have attained cosmopolitan distribution early in their history. They may therefore be expected in almost any fossiliferous bed, but on account of their simple, relatively characterless shells we often find it difficult to reach entirely satisfactory decision as to their specific and generic relations. The Cypridacea probably originated in southern seas by development out of *Aparchites*. In some of the lower and middle Ordovician species of that genus there is a tendency to a rounding of the dorsal edge and it seems but a step from these to forms in which the hingement is made by dorsal overlap of the valves. Besides the oldest of the latter forms are relatively short and thus are more nearly comparable in outline to average Aparchitidæ. Finally, so far as known, the Aparchitidæ preceded the Cypridacea.

Living genera of other families have been identified, mainly by Jones, in Paleozoic formations. Notable among these is *Cytherella, Cypridina* and *Xestoleberis*.

In all of these cases the plain shells of the Paleozoic species certainly resemble their supposed living relatives, but when there is nothing in the intervening system at all like either, some doubt as to the generic identity of the Silurian or later Paleozoic species and the living types of the genera seems pardonable.

That unquestionable Cytheracea occurred already in Paleozoic faunas is not unlikely. It is probable, if only for the reason that this superfamily is so well represented in Mesozoic and Cenozoic faunas that one cannot well escape the conviction that the Mesozoic forms were descendants of a previously well-established tribe. In any event there are a few, mostly undescribed, middle Devonian species and others in the Mississippian and Pennsylvanian that fit but poorly in the Kirkbyidæ and clearly foreshadow the Cytheracea. According to present information and referring only to described species the Cytheracea were derived out of relatively simple Kirkbyidæ, like *Youngiella,* and these out of some simple primitian stock like *Primitiella*.

From preceding statements certain generalized conclusions may be drawn. In the first place it seems reasonably certain that the Ostracoda originated in southern seas by development through early Leperditiidæ out of bivalved Branchiopoda. Next, that in the middle and later stages of the Ordovician a great expansion of the superorder both as regards variety of expression and geographic distribution occurred, all of the main Paleozoic families being introduced in this period. Third, during the middle Ordovician there seems to have been a decided shifting of the Ostracoda from the southern seas to the northern. This was accompanied by considerable changes in type. Thus while the Ostracoda of the Stones River and early Black River faunas, which are of southern origin, consist mainly of Leperditiidæ, Aparchitidæ and Eurychilininæ, the next succeeding late middle and upper Ordovician deposits in the Baltic region of Europe and in the northern areas of North America, which came in from the Arctic and north Atlantic sides, contain only few of these but instead a larger development of primitive types of Beyrichiacea. Further, all types of Ostracoda save the Leperditidæ and the already cosmopolitan genus *Eurychilina* are rare in the rocks of Trenton age in the Mississippi and Appalachian valleys. But the succeeding lithologically similar Cincinnatian deposits in the Ohio valley lack all Leperditiidæ and Eurychilininæ and almost all Aparchitidæ, whereas they show a great addition of species closely akin to the late Black River forms that are found in America north of Missouri and in the Baltic region of Europe.

In passing from the Ordovician to the Silurian the Beyrichiacea manifested also a striking structural or rather sexual change. Brood pouches were only very rarely developed in Ordovician genera and the few Ordovician instances of anything comparable to those pouches are confined to species of *Eurychilina*. However, in the Silurian representatives of the superfamily brood pouches are generally developed in what we take to be fertilized females of nearly all the Beyrichiidæ and Zygobolbidæ. The pouch was adopted at this time also by all of the surviving Eurychilininæ and occurs even in a few of the Primitiidæ, notably in the new Bollia-like genus *Bolbibollia*. In fact, the common occurrence of pouched Beyrichiacea may be accepted as a reasonably positive indication of the Silurian age of Ostracoda so provided. A clearly recognizable brood pouch is retained by only a few of the Devonian Beyrichiidæ, particularly *Treposella*, and seems to have been abandoned by all other ostracods of this and subsequent periods.

The almost total absence of Ostracoda save *Leperditia* in the North America Silurian faunas that invaded from the north and the south in contrast to their extraordinary abundance in north middle Atlantic faunas suggests a fourth conclusion, namely, that the exclusion of the ostracoda from the Gulf of Mexico in the south and the Arctic sea in the north could have been brought about only by the development of physical barriers which prevented free communication with the middle Atlantic. And this barrier lasted with but a single known and very brief interval until the Onondaga invasion from the south.

In the Devonian period the general aspect of the Ostracoda changes markedly. True Leperditiidæ have practically disappeared, only a few stragglers occurring in the lower beds of the Helderbergian. The Beyrichiidæ have evolved into new generic groups with a quite different aspect. The hitherto poorly represented genera, like *Kirkbya, Octonaria, Thlipsura,* etc., now make up a considerable portion of the total number. It appears that the area of development and dispersal was again shifted back to south and middle Atlantic waters. The general aspect of this ostracod fauna was not materially changed until the close of the Mississippian. In abundance and variety American Devonian ostracods are in contrast with those of Europe because the latter are so poorly developed.

Except as sporadic occurrences the Ostracoda are abundant in the Mississippian only in a thin zone near the top of the Kinderhook stage and in the Golconda and Glen Dean formations of the Chester series. In the Pennsylvanian a number of types not hitherto seen are introduced, the notched Cypridinoids, primitive Cytheriidæ, and numerous Cythereloids. At this time also a host of fresh-water forms are introduced—the first known. By this time the marine Ostracoda have become so cosmopolitan that the locus of their development can no longer be traced. In succeeding time the fresh-water forms become more and more abundant. They are frequently found in the Red Beds of the West, and layers are often almost made up of them in the land deposits of the Cretaceous and Tertiary. Although a few can be determined as land forms, many others are so similar to the marine Cypridæ that on their own evidence it would be almost impossible to decide that they are actually land forms and not marine.

The marine Cretaceous and Tertiary ostracods consist almost entirely of Cytheracea and Cypridæ and the general aspect of these is very similar in the two systems, the differences being only specific. A large number of these has been described from European deposits of these ages, particularly from the Paris basin of France and southern England and the Vienna basin of central Europe. Some of the American Tertiary marine representatives have been described in the Maryland reports but many others from the southern Coastal Plain remain to be described. However, the host of Cretaceous species known from American deposits are wholly untouched.

Similarly little difference can be detected between Tertiary ostracods and their modern descendants, although on account of the facilities for studying the anatomy of the soft parts it has been possible to distinguish many genera among the living forms that cannot be certainly determined among the fossil forms.

CLASSIFICATION AND DIAGNOSIS OF PALEOZOIC OSTRACODS

Family LEPERDITIIDAE Jones (restricted)

Extinct, thick-shelled ostracoda of considerable size (5-30 mm.); shell smooth and glossy, of very compact structure; valves more or less unequal, one overlapping the other on the ventral side, usually with eye tubercle, otherwise smooth or with two or three low nodes in the antero-dorsal quarter; muscle spot reticulate, flat or elevated; hinge line straight; anterior and posterior ends obliquely truncated or rounded and neither gaping nor excised. (Fig. 13.)

Genus LEPERDITIA Rouault

Shell suboblong with an oblique backward swing, usually large, commonly exceeding 8 mm. in length. Ventral edge thick, formed by the overlap of the right valve. Valves strongly unequal, the right the larger and widely overlapping the ventral edge of the left; hinge simple. A small tubercle or "eye-spot" is generally present on the antero-dorsal fourth while a large rounded subcentrally situated muscular imprint is a well marked feature of the interior and sometimes distinguishable even on the exterior.

Genotype.—Leperditia brittanica Rouault. Canadian, early Devonian.

Genus ISOCHILINA Jones

Like Leperditia except that exteriorly the valves do not overlap but seem to be equal in every respect. In reality within the left valve there is

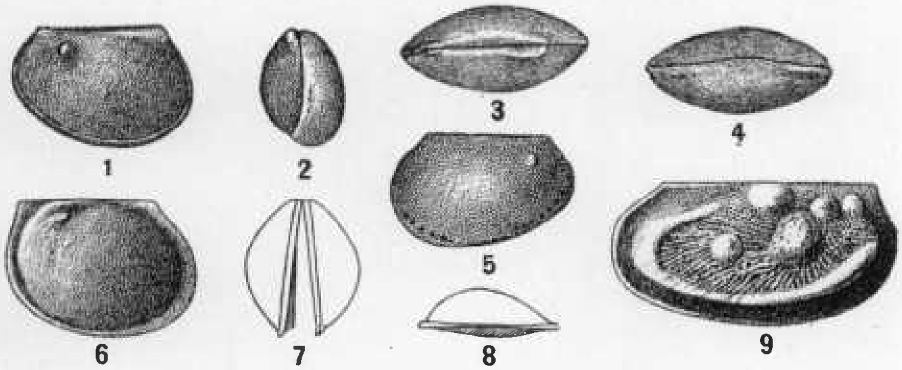

FIG. 13.—ILLUSTRATING THE FAMILY LEPERDITIIDÆ.

1-5. *Leperditia* Rouault. 1. Left side of an entire carapace of *Leperditia fabulites* Conrad, × 2, illustrating the large size, the eye spot and the characteristic overlapping ventral edge of the larger right valve. 2-4. Posterior, dorsal and ventral edge views of the same specimen. 5. Cast of the interior of the right valve, × 2, showing impression of two sets of internal papillæ along the ventral margin. Their purpose is to prevent undue overlapping of the valves. Ordovician (Black River) limestone of Minnesota.
6-8. *Isochilina* Jones. 6. Left valve of *Isachilina janesi* Wetherby, × 1.3, showing eye spot, large size and other resemblances to *Leperditia* but differing in that the two valves are nearly equal. 7. End view of two valves, separated so as to show the overlap. 8. Ventral edge view of left valve, natural size, showing sloping area which is overlapped by the right valve. Ordovician (Trenton) limestone, Harrodsburg, Kentucky.
9. *Saffordella* new genus. Complete example of left valve of genotype *Saffardella muralis* n. sp. Mohawkian (Catheys limestone) Nashville, Tenn.

a sloping area that is overlapped by a corresponding bevelled edge of the right valve. Surface sometimes lobulate or nodose.

Genotype.—Isochilina ottawa Jones. Ordovician, Silurian.

Genus SAFFORDELLA new genus

Similar to Isochilina except that the surface is more nodose and has a long curved submarginal ridge.

Genotype.—Saffordella muralis n. sp. Mohawkian (Catheys) limestone, Nashville, Tenn.

Family APARCHITIDAE new family

Simple, unsulcated, smooth ostracoda usually larger than the average size (2 to 3 mm.) with straight hinge line and thickened, often channelled, free edges, the edge of one valve sometimes slightly overlapping the other ventrally. Dorsal region often protruding over the hinge line. (Fig. 14.)

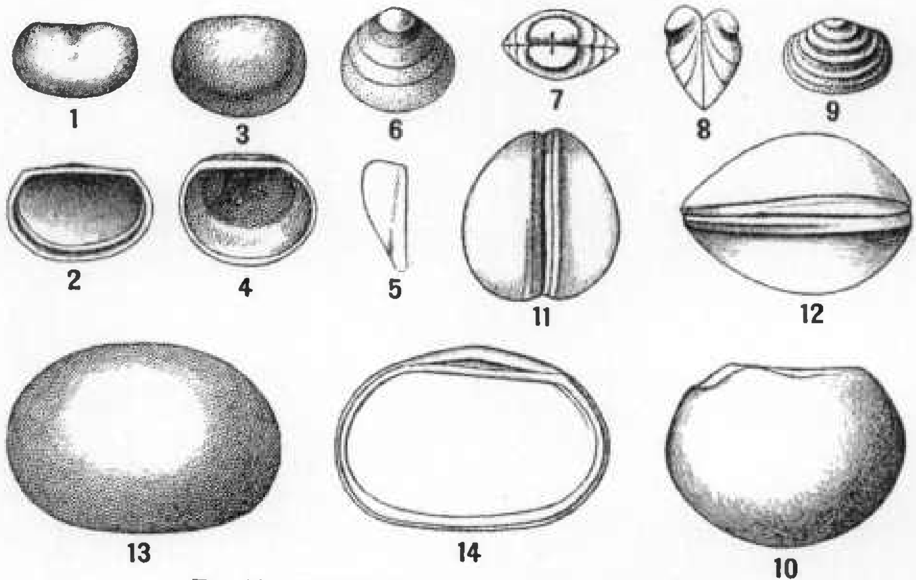

FIG. 14.—ILLUSTRATING THE FAMILY APARCHITIDÆ.

1, 2. *Leperditella* Ulrich. 1. Small left valve of *Leperditella inflata* Ulrich, × 10. 2. Interior of a large left valve of the same species, × 10, showing the marginal groove into which the free edges of the right valve fit. Ordovician (Black River) limestone, High Bridge, Kentucky.

3-5. *Schmidtella* Ulrich. 3. Exterior of right valve of the genotype *Schmidtella crassimarginata* Ulrich, × 10, showing the broad border and the gibbous dorsal region. 4, 5. Posterior edge view and interior of valve, × 10, illustrating the same features. Ordovician (Black River) limestone of Wisconsin.

6-9. *Eridoconcha* new genus. 6-8. *Eridoconcha oboloides* n. sp. distinguished by its rounded shape and few bands, the outer ones of which are simply impressed lines. 6. One valve (? right) of an entire specimen, ×20. 7. Dorsal edge view of same, with minute sulcus in rostral parts of valves. 8. End view of same. Black River (Decorah) shales, St. Paul, Minnesota. 9. Valve of *Eridoconcha rugosa* n. sp., the genotype, × 20, distinguished by ita transverse form and numerous slightly elevated concentric rings. Maysville (Corryville) division of the Ordovician at Cincinnati, Ohio.

10-12. *Aparchites Jones*. 10. Exterior of valve, × 10. 11, 12. Anterior end and ventral views of an entire example of the genotype *Aparchites whiteavesi* Jones, × 10, showing valves with thickened edge but not overlapping. Ordovician (Trenton) of Manitoba.

13, 14. *Paraparchites* Ulrich and Bassler. 9. Exterior of valve, × 20, of the genotype *Paraparchites humerosus* Ulrich and Bassler. 10. Interior of right valve, × 20, showing a linear socket for reception of edges of opposite valve. Upper Carboniferous of Kansas.

Genus APARCHITES Jones

Shell not exceeding 3 mm. in length, equivalved, subovate or oblong; hinge straight, ventral edge thickened, often bevelled or channelled; surface convex, mostly in the ventral half, smooth.

Genotype.—Aparchites whiteavesi Jones. Ordovician, Silurian.

Genus LEPERDITELLA Ulrich

Similar to Aparchites but the left valve is larger and has a groove within its ventral border into which the simple edge of the right valve is received. A more or less obscure broad depression is generally present in the central part of the dorsal half. Length 1 to 3 mm.

Genotype.—Leperditia inflata Ulrich. Ordovician, ? Silurian.

Genus SCHMIDTELLA Ulrich

Unsulcated shells, 2 mm. or less in length, short, subovate, broadly umbonate, most convex in the dorsal region and pinched in ventral slope; right valve overlapping the left along the ventral margin.

Genotype.—Schmidtella crassimarginata Ulrich. Ordovician, Silurian.

Genus ERIDOCONCHA new genus

Small, apparently unequivalved carapaces with concentric, simple or rugose bands or rows of punctæ, resembling an equilateral pelecypod or a brachiopod in shape and markings.

Genotype.—Eridoconcha rugosa n. sp. Ordovician, Silurian.

Superfamily BEYRICHIACEA

Family PRIMITIIDAE new family

Relatively simple Beyrichiacea with undefined to well defined median sulcus or simple submedian pit. (Fig. 15.)

Genus PRIMITIELLA Ulrich

Small straight-backed, equivalved shells with a broad undefined median depression mainly in the dorsal half of the valves and with narrow border.

Genotype.—Primitiella constricta Ulrich. Ordovician, Devonian.

Genus HAPLOPRIMITIA new genus

Distinguished from Primitia by the absence of a border along the free edge of valves and occurrence of a simple slit-like furrow in the dorsal half.

Genotype.—Haploprimitia (*Primitia*) *minutissima* Ulrich. Ordovician, Devonian.

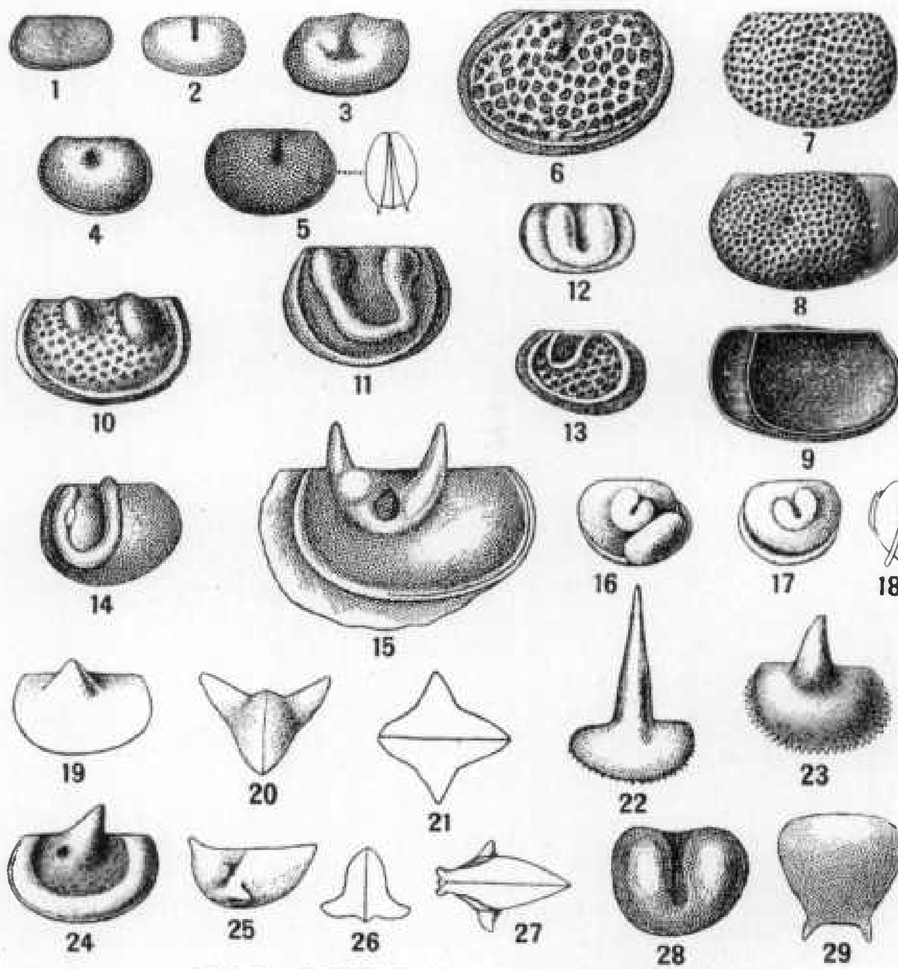

FIG. 15.—ILLUSTRATING THE FAMILY PRIMITIIDÆ.

1. *Primitiella* Ulrich. Right valve, of *Primitiella constricta* Ulrich, ×20, showing the characteristic broad undefined mesial depression. Black River (Decorah) shales, Minneapolis, Minn.
2. *Haploprimitia* new genus. Left valve of *Haploprimitia* (*Primitia*) *minutissima* Ulrich, ×40, illustrating absence of border and occurrence of simple slitlike furrow in dorsal half. Black River (Decorah) shales, Fountain, Minn.
3. *Primitia* Jones and Holl. Right valve, × 20, of *Primitia cincinnatiensis* Miller, a typical species of the genus with the low node indicated on the posterior side of the curved sulcus. Early Silurian (Richmond) shales of southwestern Ohio.
4. *Laccoprimitia* new genus. Left valve, × 20, of *Laccoprimitia* (*Primitia*) *centralis* Ulrich showing the characteristic single, simple, subcircular pit a little above the midheight, and the border. Ordovician (Trenton) limestone, West Covington, Kentucky.
5. *Euprimitia* new genus. Right valve of the type species, *Euprimitia* (*Primitia*) *sanctipauli* Ulrich, × 20, and end view of entire carapace, exhibiting the simple sulcus, the double border and the reticulate ornament. Ordovician (Black River) shales, St. Paul, Minn.
6. *Halliella* Ulrich. Right valve, x 20, of *Halliella retifera* Ulrich, the genotype illustrating the coarsely reticulate surface, the broad sulcus and the thick border. Devonian (Onondaga) limestone, Falls of the Ohio.
7-9. *Primitiopsis* Jones. Three views of the genotype *Primitiopsis planifrons* Jones, × 20. 7. Male left valve, × 20. 8, 9. Exterior and interior views of the female left valve, × 20, showing form and position of brood pouch. Silurian, Island of Gotland.
10. *Ulrichia* Jones. Left valve, × 30, of *Ulrichia conradi* Jones, showing a well-developed node on each side of a scarcely visible sulcus. Middle Devonian shales, Thedford, Ontario.
11, 12. *Bollia* Jones and Holl. 11. Right valve, × 20, of *Bollia bicollina* Jones and Holl, showing the central loop and the marginal ridge. Silurian at Wenlock, England. 12. Right valve of *Bollia ungula* Jones, × 20, showing a different expression of the genus. Devonian of Western Maryland.
13. *Placentula* Jones and Holl. Valve, enlarged, of *Placentula excavata* Jones and Holl, illustrating resemblance to *Bollia* but the loop is smaller in front of the center. Silurian of England.
14. *Jonesella* Ulrich. Right valve, × 18, of *Jonesella crepidiformis* Ulrich, with characteristic curved ridge on the posterior portion. Ordovician (Eden) shales at Cincinnati, Ohio.
15. *Dicranella* Ulrich. Right valve, × 20, of *Dicranella bicornis* Ulrich. Ordovician (Black River) shales, Minneapolis, Minn.
16-18. *Bolbibollia* new genus. Views of the genotype *Bolbibollia labrosa* n. sp., × 20. 16. Left valve of female form showing the brood pouch. 17, 18. Right valve of male and edge view of same. In this species the yokelike loop is small and low and its axis is oblique to the hinge line. The cardinal angles are very obtuse and a thick false border occurs around the ventral half. Silurian (Anticostian-Jupiter River), Jumpers, Island of Anticosti.
19-23. *Æchmina* Jones and Holl. 19-21. Lateral, end and ventral views, × 20, of *Æchmina richmondensis* n. sp., closely allied to *Æchmina bovina* Jones but longer and lacks the small spines on the ventral edge of valves. Early Silurian (Richmond-Elkhorn) Richmond, Indiana. 22. Left valve, × 20, of *Æchmina cuspidata* Jones and Holl, showing the extraordinary development of the spine. Devonian (Helderbergian) limestone of Western Maryland. 23. Left valve of the genotype *Æchmina bovina* Jones, × 30, with marginal row of spines well developed. Silurian (Wenlock) England.
24. *Paræchmina* new genus. Right valve, × 20, of *Paræchmina* (*Æchmina*) *spinosa* Hall, the genotype, illustrating the characteristic ridge along the free edge, the spine and the pit near its base. Silurian (Rochester shale) Lockport, N. Y.
25-27. *Acronotella* new genus. Lateral, end and ventral views of the genotype *Acronotella shideleri* n. sp., × 20. Early Silurian (Richmond-Elkhorn) Richmond, Ind.
28. *Dilobella* Ulrich. Valve, × 20, of *Dilobella typa* Ulrich, illustrating the two large subequal lobes separated by a deep subcentral sulcus. Ordovician (Back River) shales, St. Paul, Minn.
29. *Bursulella* Jones. Valve of *Bursulella triangularis* Jones, × 30. Silurian, Island of Gotland.

Genus PRIMITIA Jones and Holl

Distinguished from Primitiella by having a well-marked subcentral, usually curved sulcus with undefined swellings or low nodes on one or both sides of it instead of an undefined depression. As a rule also the valves are shorter, the outline being generally more ovate.

Genotype.—Primitia mundula Jones. Ordovician, Permian.

Genus LACCOPRIMITIA new genus

Valves with a border along the free edge, a single, simple subcircular pit a little above the mid-height and without surface nodes. Otherwise as in Primitia.

Genotype.—Laccoprimitia (*Primitia*) *centralis* Ulrich. Ordovician, Carboniferous.

Genus EUPRIMITIA new genus

Like typical Primitia except that the carapace has a simple sulcus, reticulate ornamentation and an elevated false border around the free edge of the valve, making a bicanaliculate edge in the entire closed carapace.

Genotype.—Euprimitia (*Primitia*) *sanctipauli* Ulrich. Ordovician, Silurian.

Genus HALLIELLA Ulrich

Like Euprimitia but with broader sulcus and very coarsely reticulate surface which rises to greatest height in antero-dorsal quarter. Thick double border.

Genotype.—Halliella retifera Ulrich. Ordovician, Devonian.

Genus PRIMITIOPSIS Jones

Oblong, strongly convex, borderless shells with a sharply defined but small, deep, subcentral pit and reticular ornament. In the female a rather wide internally concave and distinctly smooth area along the posterior side represents the brood pouch. Female, therefore, much longer than the male.

Genotype.—Primitiopsis planifrons Jones. Silurian, Devonian.

Genus ULRICHIA Jones

Differs from Primitia by having a sharply defined node on each side of the sulcus, which in this case is scarcely impressed. Occasionally other nodes are present on the ventral half of the surface.

Genotype.—Ulrichia conradi Jones. Ordovician, Devonian.

Genus BOLLIA Jones and Holl

Distinguished by a centrally situated loop-like or horseshoe-shaped ridge, the free upper extremities of which are often bulbous; a more or less complete marginal ridge may be present or wanting.

Genotype.—Bollia uniflexa Jones and Holl. Ordovician, Carboniferous.

Genus PLACENTULA Jones and Holl

Probably related to Bollia but differing in having the " loop " generally in front of the center and close to the dorsal margin. As a rule a rim-like ridge parallels the outer border of the valves.

Genotype.—Placentula excavata Jones and Holl. Ordovician, Silurian.

Genus JONESELLA Ulrich

Small oblong or subovate borderless ostracoda distinguished by a horseshoe or L-shaped ridge on the posterior two-thirds.

Genotype.—Jonesella crepidiformis Ulrich. Ordovician, Silurian.

Genus DICRANELLA Ulrich

Distinguished from Ulrichia in having one or both nodes developed into long, horn-like, diverging prominences and usually with a broad frill-like border along the free edge of valves.

Genotype.—Dicranella bicornis Ulrich. Ordovician.

Genus BOLBIBOLLIA new genus

Like Bollia but males and females distinct, the latter with brood pouch.

Genotype.—Bolbibollia labrosa n. sp. Early Silurian.

Genus AECHMINA Jones and Holl

Straight hinged, simply convex ostracoda without pit or sulcus and lobation confined to a single, sometimes enormously developed horn-like process.

Genotype.—Aechmina bovina Jones and Holl. Ordovician, Devonian.

Genus PARAECHMINA new genus

Differs from Aechmina in having a well defined ridge-like elevation along the free edge of the valve and in the development of a pit on the posterior side of the base of the spine.

Genotype.—Paræchmina (Aechmina) spinosa Hall. Silurian, Devonian.

Genus ACRONOTELLA new genus

Simple, unbordered ostracoda with long hinge and produced dorsal extremities, crossed obliquely by a sharp sulcus dividing the larger, evenly convex anterior part from the smaller more compressed posterior side. A low node just beneath the middle of the sulcus and beneath this and close to the ventral edge, a thick spine.

Genotype.—Acronotella shideleri n. sp. Early Silurian.

Genus DILOBELLA Ulrich

Subovate or somewhat reniform bilobed shells; lobes very large, subequal and almost completely separated by a deep subcentral vertical or oblique sulcus.

Genotype.—Dilobella typa Ulrich. Ordovician.

Genus BURSULELLA Jones

Small bivalved carapaces (possibly not ostracodal) with more or less triangular equilateral valves which have one or more horn-like projections on the ventral edge of each valve.

Genotype.—Bursulella triangularis Jones. Silurian.

Subfamily EURYCHILININAE new subfamily

Large Primitiidæ with a broad frill along the free edge of the valves. (Fig. 16.)

Genus EURYCHILINA Ulrich

Oblong or semielliptical, long-hinged shells having a subcentral Primitian sulcus, the posterior edge of which is often raised into a small rounded node; free margins provided with a wide, usually radiately plicated, frill-

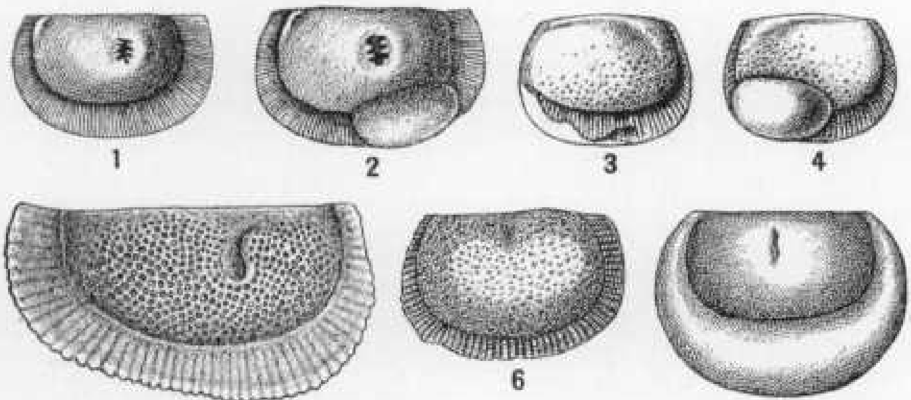

FIG. 16.—ILLUSTRATING THE SUBFAMILY EURYCHILININÆ.

1, 2. *Chilobolbina* new genus. Left valve, × 15 of the genotype *Chilobolbina* (*Primitia*) *dentifera* Bonnema, showing the male and female forms respectively. Ordovician (Kuckers formation), Kuckers, Esthonia.
3, 4. *Apatobolbina* new genus. 3. Male valve, ×12 of the genotype *Apatobolbina granifera* n. sp. showing convex surface without sulcus. 4. Right valve of female form, × 12, illustrating character of brood pouch. Upper Clinton (*Mastigobolbina typus* zone) near Hollidaysburg, Pa.
5. *Eurychilina* Ulrich. Left valve, × 20, of the genotype *Eurychilina reticulata* Ulrich, illustrating the sulcus and node on the valve and the wide frill-like border. Ordovician (Black River-Decorah shales), Fillmore Co., Minn.
6. *Apatochilina* new genus. Left valve of the genotype *Apatochilina* (*Eurychilina*) *obesa* Ulrich, × 18, with sulcus and node wanting. Ordovician (Black River-Lowville limestone), High Bridge, Kentucky.
7. *Cœlochilina* new genus. Right valve of the genotype *Cœlochilina* (*Eurychilina*) *æqualis* Ulrich, × 18, with simple sulcus developed. Ordovician (Stones River-Lebanon limestone), High Bridge, Kentucky.

like border curved on its under side so as to form a concave area around the true contact edges of the valves.

Genotype.—Eurychilina reticulata Ulrich. Ordovician, early Silurian.

Genus COELOCHILINA new genus

Carapace similar to Eurychilina but with only a simple sulcus and lacking the node.

Genotype.—Cœlochilina (*Eurychilina*) *æqualis* Ulrich. Ordovician.

Genus CHILOBOLBINA new genus

Like Cœlochilina in many respects but a long ovate brood pouch is developed in the posterior three-fifths of the ventral part of the frill.

Genotype.—Chilobolbina (*Primitia*) *dentifera* Bonnema. Ordovician, Silurian.

Genus APATOCHILINA new genus

Similar to Eurychilina but the node is missing, the border is not incurved, and the sulcus is represented by a dorsal undefined depression, the surface of the valves being more evenly convex.

Genotype.—Apatochilina (*Eurychilina*) *obesa* Ulrich. Ordovician.

Genus APATOBOLBINA new genus

Like Apatochilina but an oval brood pouch is developed in the female on the postventral half of the frill and on a part of the adjacent convex area.

Genotype.—Apatobolbina granifera n. sp. Silurian.

Family ZYGOBOLBIDAE new family

Beyrichiacea with lobate valves; lobes two, three, or four in number, the posterior the most unstable, the anterior lobe divided in the quadrilobate genera, the anterior and median ones commonly broadly or narrowly confluent below. Brood pouch present as an added lobe or undefined swelling along the posterior edge or on the post-ventral slope. (Fig. 17.)

Subfamily ZYGOBOLBINAE new subfamily

Carapace having an emaciated appearance with narrow lobes and wide sulci, the posterior lobe weak and commonly obsolete, the anterior and median lobes uniting below to form a thin U-shaped ridge.

Genus ZYGOBOLBA new genus

Zygobolbinæ with posterior lobe present but weak and the brood pouch a well defined, acuminate-ovate swelling on the outer two-thirds of the post-ventral quarter.

Genotype.—Zygobolba (*Beyrichia*) *decora* Billings. Clinton.

Genus ZYGOBOLBINA new genus

Like Zygobolba but larger, the posterior lobe usually nearly or quite obsolete, and the brood pouch of the female unequally bilobed.

Genotype.—Zygobolbina conradi n. sp. Clinton.

Genus ZYGOSELLA new genus

Similar to Zygobolba but the brood pouch is a narrow ridge-like elevation paralleling the posterior border.

Genotype.—Zygosella vallata n. sp. Clinton.

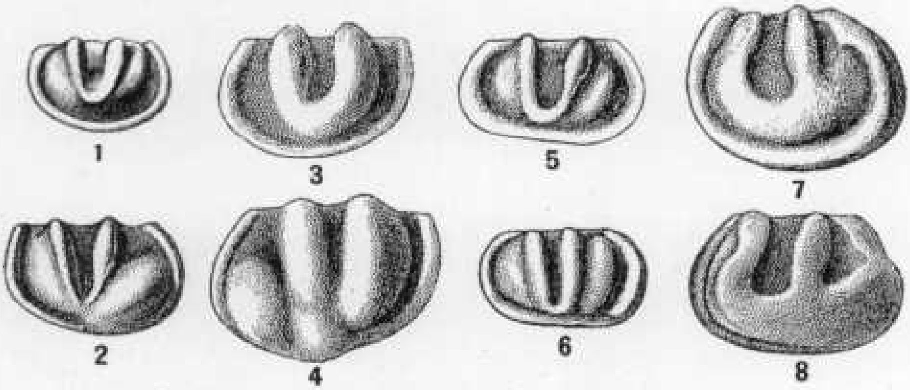

FIG. 17.—ILLUSTRATING THE FAMILY ZYGOBOLBIDÆ.

1, 2. *Zygobolba* new genus. 1. Male left valve, × 8 of the genotype *Zygobolba (Beyrichia) decora* Billings, illustrating development of lobes. 2. Left valve, female of the same species, × 8, showing the ovate brood pouch in the post ventral quarter. Silurian (Jupiter River formation), Island of Anticosti.
3, 4. *Zygobolbina* new genus. Right valves of male and female forms, of genotype, × 8, *Zygobolbina conrodi* n. sp., the latter illustrating the unequally bilobed brood pouch. Middle Clinton (Mastigobolbina lata zone), Armuchee, Ga.
5, 6. *Zygosella* new genus. Left valve, male, of the genotype *Zygosella vallata* n. sp., × 8, from the Upper Cilnton (Mastigobolbina typus zone) 2 miles east of Great Cacapon, West Virginia. 6. Left valve, female, × 8, of *Zygosella macra* n. sp., exhibiting the narrow ridge-like brood pouch paralleling the posterior border. Upper Clinton (Mastigobolbina typus zone), North of Williamsville, Virginia.
7, 8. *Bonnemaia* new genus. Left valves, male, × 8, and female, × 6, of *Bonnemaia rudis* n. sp. Upper Clinton (Bonnemaia rudis zone), Powell Mountain, 5 miles N. W. Sneedville, Tennessee.

Genus BONNEMAIA new genus

Very large Zygobolbinæ with median sulcus short and the U-shaped lobe thick, its posterior limb often divided in its upper half by a short posterior sulcus and the anterior lobe usually crowned with a sigmoidally-curved angular crest. Brood pouch large, indefinitely outlined on the inner side, situated as in Zygobolba, in the post-ventral quarter.

Genotype.—Bonnemaia celsa n. sp. Clinton.

Subfamily KLOEDENINAE new subfamily

Ventrally rather obese with relatively short narrow sulei and more or less confluent lobes, the posterior lobe usually large and thick. (Fig. 18.)

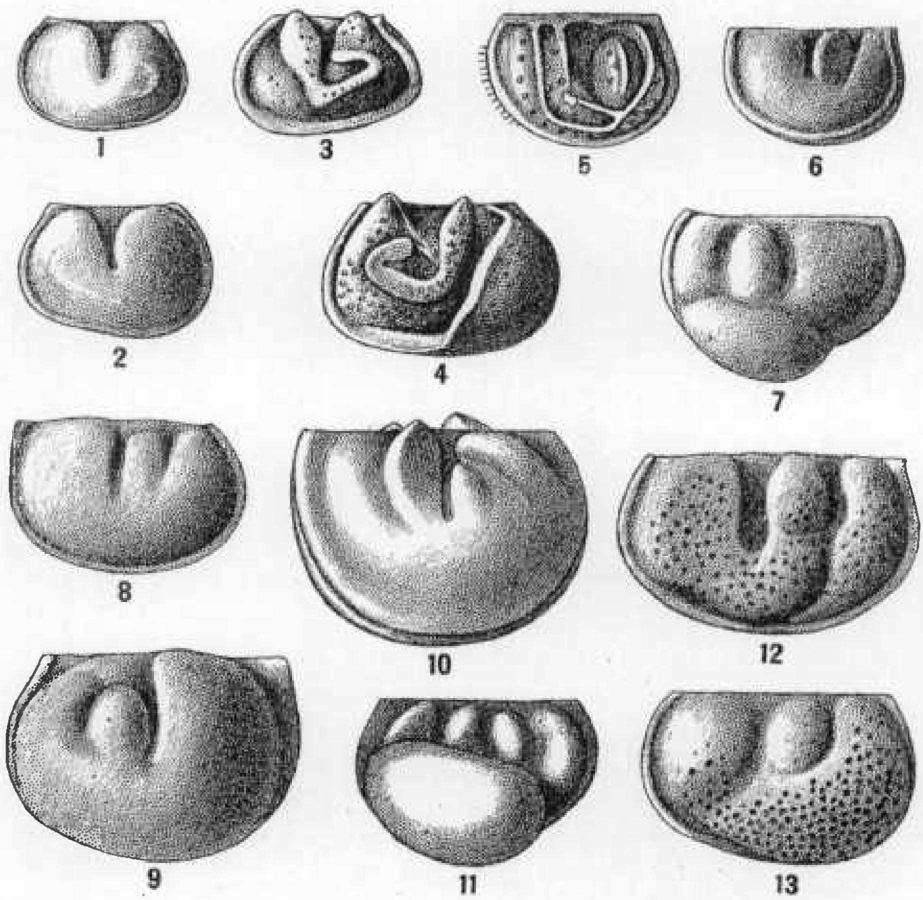

FIG. 18.—ILLUSTRATING THE SUBFAMILY KLŒDENINÆ.

1, 2. *Plethobolbina* new genus. 1. Small perfect right valve, × 6 of the genotype *Plethobolbina typicalis* n. sp. 2. Large left valve, × 6, possibly representing the female. Upper Clinton (Mastigobolbina typus zone), Lakemont, Pa., and Great Cacapon, West Virginia.
3, 4. *Mastigobolbina* new genus. 3. Male right valve, × 6 of *Mastigobolbina typus* var. *angulata*. 4. Left valve of female, × 8, of the genotype *Mastigolbolbina typus* n. sp. Upper Clinton (Mastigobolbina typus zone), Pennsylvania and Maryland.
5. *Steusloffia* Ulrich and Bassler. Left valve of the genotype *Steusloffia linnarssoni* (Krause), × 20. Ordovician drift of Northern Germany.
6, 7. *Klœdenia* Jones and Holl. 6. Left valve, male, × 12, of *Klœdenia normalis* n. sp. 7. Right valve, female of same, × 20, with brood pouch. Silurian (Wills Creek formation), Pinto, Maryland.
8, 9. *Welleria* new genus. Left valve male and right valve female, × 12 of the genotype *Welleria obliqua* n. sp. Silurian (Tonoloway limestone) Western Maryland.
10, 11. *Kyammodes* Jones. 10. Valve of male, magnified, of *Kyammodes whidbornei* Jones, the genotype from the Devonian of Devonshire, England. 11. Right valve, female, × 10, of *Kyammodes* (*Klœdenia*) *kiesoui* (Krause) from the Silurian drift of northern Germany.
12, 13. *Zygobeyrichia* Ulrich. Male and female left valves, × 12, of *Zygobeyrichia ventripunctata* n. sp. Silurian (Tonoloway limestone), Keyser, West Virginia.

Genus PLETHOBOLBINA new genus

Carapace large, obese, primitian in aspect, the lobes submerged with only the median sulcus remaining; curved crest on anterior lobe barely indicated. Females differing only in slightly greater fullness of post-ventral part.

Genotype.—Plethobolbina typicalis n. sp. Clinton.

Genus MASTIGOBOLBINA new genus

Large trilobate Klœdeninæ with a narrow posterior lobe, a much larger and irregularly-shaped anterior lobe and a pyriform median lobe, the latter tapering below and passing into a whiplash-like raised extension that turns obliquely forward and upward and then backward again across the anterior lobe. Brood pouch large, posterior in position, covering summit of posterior lobe, its inner side sharply defined by the posterior sulcus.

Genotype.—Mastigobolbina typus n. sp. Clinton.

Genus KLŒDENIA Jones and Holl

Obese carapaces like Plethobolbina and approaching the simple forms of Mastigobolbina in having both median and posterior sulci and the median lobe partly separated as a rounded or subovate node; sulci short, confined to the dorsal half. Brood pouch well developed, large and rather distinctly outlined, projecting beyond the ventral edge and most of it behind the midlength of valves.

Genotype.—Klœdenia wilckensiana Jones. Silurian, Devonian.

Genus WELLERIA new genus

Similar to Klœdenia but the brood pouch forms a low broad inwardly undefined, swelling affecting the ventral half or two-thirds of the valves and projecting slightly beyond the edge.

Genotype.—Welleria obliqua n. sp. Late Silurian.

Genus KYAMMODES Jones

Similar to Welleria but having two additional short sulci produced by incipient division of the anterior and posterior lobes. Brood pouch strongly convex, sharply defined, very large, covering nearly half the valve and projecting beyond the border.

Genotype.—Kyammodes whidbornei Jones. Late Silurian, Devonian.

Genus ZYGOBEYRICHIA Ulrich

Like Klœdenia except that the sulci are larger and the posterior one extends to the ventral border, leaving the anterior and median lobes yoked together. The brood pouch also is undefined on its inner side and larger.

Genotype.—Zygobeyrichia apicalis Ulrich. Silurian, Devonian.

Genus STEUSLOFFIA Ulrich and Bassler

Valves similar to Klœdenia and Beyrichia but traversed by thin elevated crest-like ridges.

Genotype.—Steusloffia (*Beyrichia*) *linnarssoni* Krause. Ordovician.

Subfamily DREPANELLINAE new subfamily

Typically quadrilobate, the anterior lobe divided or broken up into lobes or nodes, the median lobe isolated, the posterior lobe narrow and prolonged as a sickle-shaped ridge around the ventral side; rarely the posterior lobe is completely submerged and the other two lobes reduced to small rounded subcentral nodes. Brood pouch elongate, confined to ventral side. (Fig. 19.)

Genus DREPANELLA Ulrich

Depressed convex, suboblong valves with a more or less complete, often sickle-shaped, sharply elevated marginal ridge, within which the surface exhibits two or more usually isolated nodes; ventral edge thick; brood pouch unknown, probably wanting.

Genotype.—Drepanella crassinoda Ulrich. Ordovician, early Silurian.

Genus DREPANELLINA new genus

Similar to Drepanella but the female is provided with a brood pouch that appears as an indefinite swelling over the ventrally confluent ridges.

Genotype.—Drepanellina clarki n. sp. Middle Silurian.

Genus SCOFIELDIA Ulrich and Bassler

Like Drepanella but with median lobe small and located near middle of dorsal edge, and the anterior and posterior lobes symmetrically arranged and irregularly triangular in form; near the ventral edge a thick, sharply elevated bar-like ridge.

Genotype.—Scofieldia (Drepanella) bilateralis Ulrich. Ordovician.

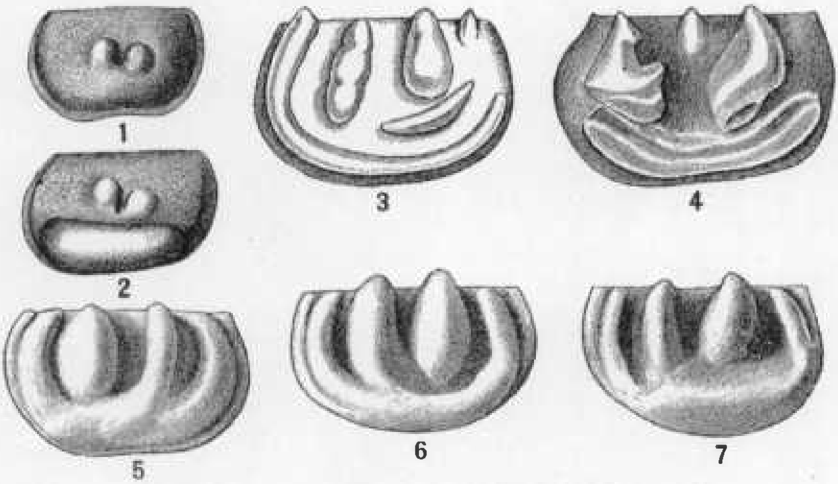

FIG. 19.—ILLUSTRATING THE SUBFAMILY DREPANELLINÆ.

1, 2. *Mesomphalus* Ulrich and Bassler. Right valves, × 12, male and female of the genotype *Mesomphalus hartleyi* Ulrich and Bassler, the latter showing the brood pouch. Devonian (Helderbergian-Keyser member), Cumberland, Maryland.
3. *Drepanella* Ulrich. Right valve, × 12, of the genotype *Drepanella crassinoda* Ulrich. Ordovician (Black River-Lowville limestone), High Bridge, Kentucky.
4. *Scofieldia* Ulrich and Bassler. Right (?) valve, × 12, of *Scofieldia (Drepanella) bilateralis* Ulrich, the genotype. Ordovinian (Black River-Decorah shale), St. Paul, Minn.
5-7. *Drepanellina* new genus. 5. Well-preserved right valve, male, × 8, of the genotype *Drepanellina clarki* n. sp. 6. Left valve, male, × 8, showing the resemhlance to *Drepanella*. 7. Left valve, female, × 8, showing the ventral brood pouch. Upper Clinton (*Drepanellina clarki* zone), Cumberland, Maryland.

Genus MESOMPHALUS Ulrich and Bassler

Carapace obese, the posterior lobe completely submerged, the median and anterior lobes reduced to small, rounded, closely approximated subcentrally situated nodes separated by a short pit-like sulcus. Brood pouch sausage-shaped, uncommonly prominent and well defined, located on the ventral slope.

Genotype.—Mesomphalus hartleyi Ulrich and Bassler. Early Devonian.

Family BEYRICHIIDAE Jones (restricted)

Valves trilobate or quadrilobate, deeply sulcated; brood pouch when present, very prominent, subglobular or egg-shaped, on the ventral slope. (Fig. 20.)

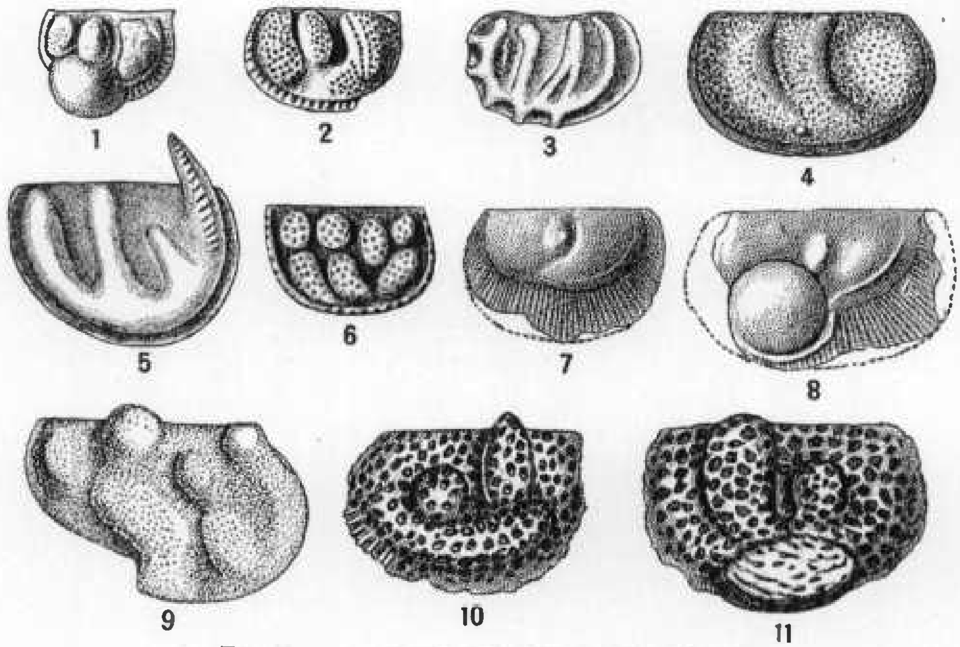

FIG. 20.—ILLUSTRATING THE FAMILY BEYRICHIIDÆ.

1, 2. *Beyrichia* McCoy. Female and male valves, × 12, of *Beyrichia veronica* n. sp., the former with the test in part removed. Upper Clinton (*Drepanellina clarki* zone), Western Maryland.
3. *Tetradella* Ulrich. Right valve of the genotype *Tetradella* (*Beyrichia*) *quadrilirata* Hall and Whitfield. Ordovician (Black River-Decorah shale), Minneapolis, Minn.
4. *Ctenobolbina* Ulrich. Left valve, × 15, of the genotype *Ctenobolbina ciliata* (Emmons). Ordovician (Cincinnatian-Eden shale), Cincinnati, Ohio.
5. *Ceratopsis* Ulrich. Left valve, × 20, of the genotype *Ceratopsis chambersi* (Miller). Ordovician (Black River-Decorah shale), St. Paul, Minn.
6. *Kiesowia* Ulrich and Bassler. Left valve, × 10, of the genotype *Kiesowia* (*Beyrichia*) *dissecta* Krause. Silurian drift of northern Germany.
7, 8. *Dibolbina* new genus. Right valves, × 20, male and female, of the genotype *Dibolbina cristata* n. sp., showing the surface characters, broad frill and in the latter, the hemispherical, posterior brood pouch. Silurian (Tonoloway limestone), Keyser, West Virginia.
9. *Hollina* Ulrich and Bassler. Left valve, × 20 of the genotype *Hollina* (*Ctenobolbina*) *insolens* Ulrich. Devonian (Onondaga limestone), Falls of the Ohio River.
10, 11. *Treposella* Ulrich and Bassler. 10. Right valve, male, × 20, of *Treposella* (*Beyrichia*) *lyoni* Ulrich. 11. Left valve, female, × 20, of the same species, with the brood pouch near middle of ventral edge. Devonian (Onondaga limestone), Falls of the Ohio River.

Genus BEYRICHIA McCoy

Distinctly trilobate, the middle lobe smallest, rounded and commonly isolated, the posterior longer but also detached. Brood pouch subglobular or ovate, more or less posterior in position.

Genotype.—Beyrichia klœdeni McCoy. Silurian, Devonian.

Genus TETRADELLA Ulrich

Valves marked by four or less curved, vertical ridges ventrally united; one or both of the inner ridges sometimes duplex.

Genotype.—Tetradella (*Beyrichia*) *quadrilirata* Hall and Whitfield. Ordovician, early Silurian.

Genus CTENOBOLBINA Ulrich

Middle lobe more or less completely confluent with the posterior lobe, the composite lobe bulbous and sharply defined in front by a deep curved sulcus; the anterior lobe divided by an oblique furrow. Free edges with false border or frill.

Genotype.—Ctenobolbina (*Beyrichia*) *ciliata* Emmons. Ordovician, Devonian.

Genus CERATOPSIS Ulrich

Distinguished from Tetradella by the remarkable process which arises from the dorsal extremity of the posterior ridge. This may be straight and horn-like with one of the edges toothed, or expanded somewhat mushroom-like.

Genotype.—Ceratopsis (*Beyrichia*) *oculifera* Hall. Ordovician, Silurian.

Genus KIESOWIA Ulrich and Bassler

Like Tetradella except that the two anterior and the posterior lobes are each divided into two or three nodes.

Genotype.—Kiesowia (*Beyrichia*) *dissecta* Krause. Silurian.

Genus DIBOLBINA new genus

Widely frilled Beyrichiidæ with trilobation of surface much obscured, only the middle lobe being definitely developed. Brood pouch nearly hemispheric, mainly posterior in position.

Genotype.—Dibolbina cristata n. sp. Late Silurian.

Genus HOLLINA Ulrich and Bassler

Allied to Ctenobolbina but the posterior lobe is commonly broken up into three or four nodes of which the inner one is the most pronounced and most persistent; the middle lobe terminates dorsally in a large rounded node and the anterior lobe is reduced to a small node or is obsolete. Marginal frill confined chiefly to the posterior two-thirds. Brood pouch not developed.

Genotype.—Hollina (*Ctenobolbina*) *insolens* Ulrich. Devonian, Mississippian.

Genus TREPOSELLA Ulrich and Bassler

Like Beyrichia except that the posterior lobe is obsolete in the post dorsal quarter but well developed along the ventral side, the middle lobe is prominent and rounded and the anterior lobe is reduced to a vertically elongated node. Between the latter two is a definite pit. Brood pouch near middle of ventral edge instead of distinctly posterior.

Genotype.—Treposella (*Beyrichia*) *lyoni* Ulrich. Middle Devonian.

Family KLŒDENELLIDAE new family

Straight-hinged, more or less inequivalved small ostracoda, usually the right valve overlapping the left around the free edges and provided with a small process in the post-dorsal angle that fits into a corresponding depression in the opposite valve. Valves shallowly unisulcate to deeply quadrilobate with practically complete transition from the one extreme to the other. (Fig. 21.)

Genus EUKLŒDENELLA new genus

Surface of valves evenly convex or with only a median pit or sulcus and more rarely with a shallow depression in the ventral slope.

Genotype.—Euklœdenella umbilicata n. sp. Silurian.

Genus KLŒDENELLA Ulrich and Bassler (restricted)

Surface of valves with a median and a posterior sulcus both usually confined to the post-dorsal quarter; otherwise like Euklœdenella.

Genotype.—Klœdenella pennsylvanica Jones. Silurian, Devonian.

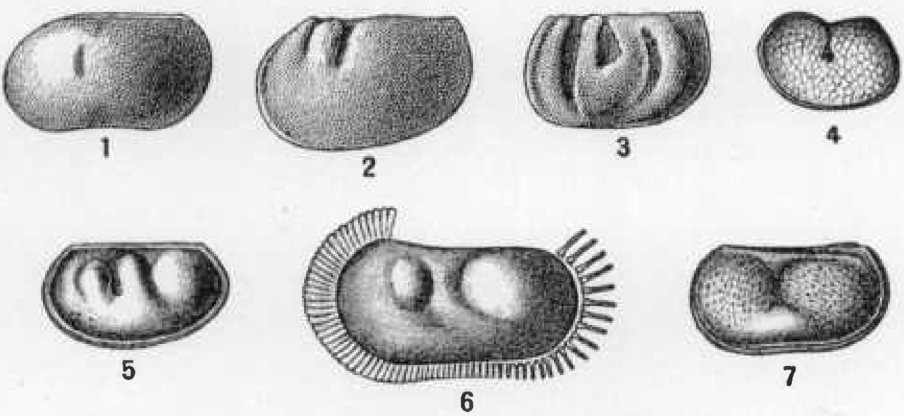

FIG. 21.—ILLUSTRATING THE FAMILY KLŒDENELLIDÆ.

1. *Euklœdenella* new genus. Right side of a complete carapace, × 16, of the genotype *Euklœdenella umbilicata* n. sp., illustrating obsolete lobation of valves. Silurian (Cayugan-McKenzie formation), Flintstone, Maryland.
2. *Klœdenella* Ulrich and Bassler. Right valve, × 20, of *Klœdenella obliqua* n. sp. exhibiting the characteristically short median and posterior sulci limited to the post dorsal quarter. Silurian (Cayugan-Tonoloway limestone), Cumberland, Maryland.
3. *Dizygopleura* new genus. Right valve of *Dizygopleura stosei* n. sp., × 20. showing the typical quadrilobate surface. Silurian (Cayugan-McKenzie formation), 1½ miles east of Great Cacapon, West Virginia.
4. *Kirkbyina* Ulrich and Bassler. Left valve, × 25, of the genotype *Kirkbyina (Beyrichiella) reticosa* Jones and Kirkby. Carboniferous of Great Britain.
5. *Jonesina* Ulrich and Bassler. Right valve, × 25, of tbe genotype *Jonesina (Beyrichia) fastigiata* Jones and Kirby. Carboniferous of Scotland.
6. *Beyrichiopsis* Jones and Kirkby. Apparently perfect, right valve, × 40, of the genotype *Beyrichiopsis fimbriata* Jones and Kirkby. Carboniferous of Scotland.
7. *Bevrichiella* Jones and Kirkby. Right valve, × 20, of the genotype *Beyrichiella cristata* Jones and Kirkby. Carboniferous of Scotland.

Genus DIZYGOPLEURA new genus

Distinguished from Klœdenella by the more or less distinct quadrilobation of the valves, the posterior sulcus being much longer, the median sulcus longer, and the anterior lobe more or less completely divided by another sulcus.

Genotype.—Dizygopleura swartzi n. sp. Silurian, Devonian.

Genus JONESINA Ulrich and Bassler

Like Klœdenella but the overlap of the valves is reversed, the left valve overlapping the right.

Genotype.—Jonesina (*Beyrichia*) *fastigiata* Jones and Kirkby. Carboniferous.

Genus KIRKBYINA Ulrich and Bassler

Carapace small, less than 1 mm. in length, rather short, subovate to subquadrate, ventricose, thickest anteriorly, with a simple primitian sulcus about the middle of the dorsal half. Valves unequal, the right slightly larger and overlapping the edges of the left.

Genotype.—Kirkbyina (*Beyrichiella*) *reticosa* Jones and Kirkby. Carboniferous.

Genus BEYRICHIELLA Jones and Kirkby

Carapace small, 1 mm. or less in length, elongate subquadrate, thickest anteriorly, with a rather broad median sulcus giving the shell a bilobed aspect; a low, transverse ridge in the ventral part cuts off the sulcus and unites the lower parts of the two lobes. Valves unequal, the edge of the smaller right valve being set into the overlapping ventral and end parts of the large left valve.

Genotype.—Beyrichiella cristata Jones and Kirkby. Carboniferous.

Genus BEYRICHIOPSIS Jones and Kirkby

Like Beyrichiella but lacking the transverse ridge and having a small rounded post-median lobe. A wide radiated marginal fringe is present.

Genotype.—Beyrichiopsis fimbriata Jones and Kirkby. Carboniferous.

Family KIRKBYIDAE Ulrich and Bassler

A most variable and probably unnatural association of equivalved genera of Beyrichiacea tending toward the Cytheracea. Typically with a distinct false border and a subcentral well defined pit and often with concentric or transverse more or less parallel ridges. (Fig. 22.)

Genus YOUNGIELLA Jones and Kirkby

Simple unadorned valve with long straight, internally denticulated hinge.

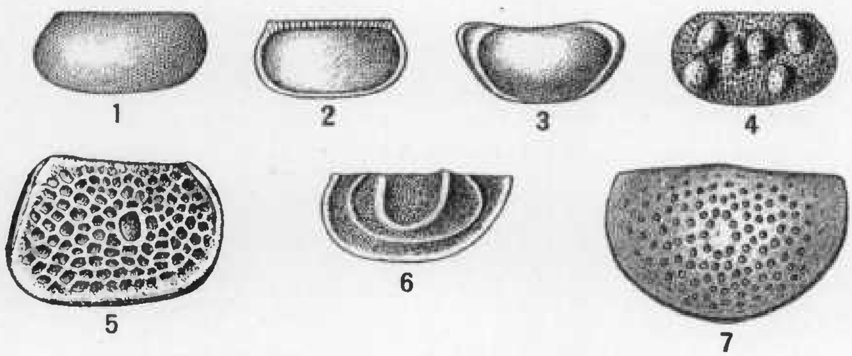

FIG. 22.—ILLUSTRATING THE FAMILY KIRKBYIDÆ.

1, 2. *Youngiella* Jones and Kirkby. Right (?) valve of the genotype *Youngiella* (*Youngia*) *rectidorsalis* Jones and Kirkby, × 50. 2. Interior of valve showing teeth along the hinge. Carboniferous of England.
3. *Moorea* Jones and Kirkby. Left valve of the genotype *Moorea obesa* Jones and Kirkby, magnified. Carboniferous of England.
4. *Mauryella* new genus. Left valve of the genotype *Mauryella mammillata* n. sp., × 20, showing the absence of a false border, and the presence of a subcentral pit, reticulate surface with six prominent rounded nodes. Mississippian (Kinderhook-Ridgetop shale), Mt. Pleasant, Maury County, Tennessee.
5. *Kirkby* Jones. Right valve, × 20, of *Kirkbya subquadrata* Ulrich. Devonian (Onondaga limestone), Falls of the Ohio River.
6. *Strepula* Jones and Holl. Right valve of the genotype *Strepula concentrica* Jones and Holl, × 20, with the characteristic crest-like ridges. Silurian of England.
7. *Macronotella* Ulrich. Valve (right?), × 20, of the genotype *Macronotella scofieldi* Ulrich. Ordovician (Black River limestone), Cannon Falls, Minnesota.

Genotype.—Youngiella (*Youngia*) *rectidorsalis* Jones and Kirkby. Carboniferous.

Genus MOOREA Jones and Kirkby

Small, more or less oblong or ovate shells; valves compressed convex, the free edges bounded by a raised marginal ridge, sometimes wanting along the ventral side; inner region flat or gently convex, without nodes, sulcus or pit.

Genotype.—*Moorea obesa* and *M. tenuis* Jones and Kirkby. Ordovician, Carboniferous.

Genus KIRKBYA Jones

Distinguished from Moorea by the presence of a subcentral pit. Surface ornament usually reticulated.

Genotype.—*Kirkbya permiana* Jones. Silurian, Permian.

Genus MAURYELLA new genus

Like Kirkbya except that valves have no false border and the surface bears five or six strongly elevated rounded nodes arranged without special order.

Genotype.—*Mauryella mammilata* n. sp. Mississippian of Tennessee.

Genus STREPULA Jones and Holl

Suboblong shells, valves slightly convex without sulcus, traversed by two or more concentric or twisted, thin crest-like ridges.

Genotype.—*Strepula concentrica* Jones and Holl. Silurian, Devonian.

Genus MACRONOTELLA Ulrich

Shell semicircular or semiovate with a long, nearly straight hinge; valves equal, inflated centrodorsally, without ridges or sulcus but exhibiting a smooth, subcentral spot where the reticular ornament is omitted.

Genotype.—*Macronotella scofieldi* Ulrich. Ordovician.

Superfamily CYPRIDACEA

Family THLIPSURIDAE Jones

Reniform or ovate inequivalved shells less than 2 mm. in length, the margin of one valve overlapping that of the other more or less completely. Dorsal margin arcuate, ventral sometimes straight or even slightly sinuate;

surface with two or more definite pits. Determination of right and left valve arbitrarily made. (Fig. 23.)

Genus THLIPSURA Jones and Holl

Oval to reniform shells; each valve generally with three pits, one posterior and two in the anterior half; surface without ornament.

Genotype.—Thilipsura corpulenta Jones and Holl. Silurian, Devonian.

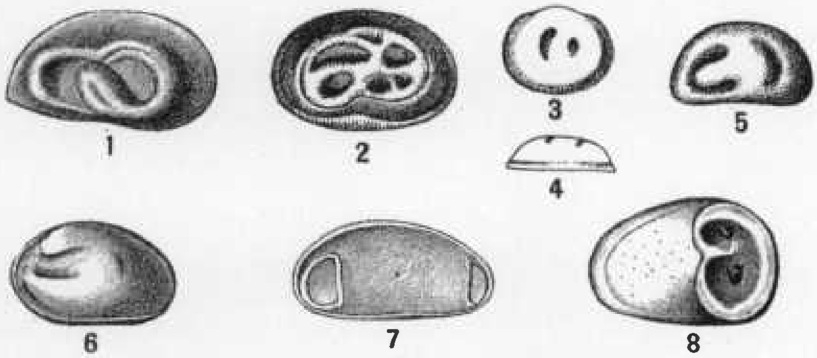

FIG. 23.—ILLUSTRATING THE FAMILY THLIPSURIDÆ.

1-4. *Octonaria* Jones. 1. Left valve of the genotype *Octonaria octoformis* Jones, × 20, showing the typical 8-shaped annular ridge. Silurian of England. 2. An American species of *Octonaria* (*O. ovata* Ulrich), × 20, in which the 8-shaped ridge is more modified. Devonian (Onondaga limestone), Falls of the Ohio. 3, 4. The overlapping valve and edge view of same, × 20, of a simple species, *Octonaria bicava* n. sp., distinguished by the two median cavities. The other valve lacks the slight dorsal angles. Cincinnatian (Southgate member of Eden shale), Covington, Kentucky.
5, 6. *Thlipsura* Jones and Holl. 5. Left valve of *Thlipsura v-scripta* var. *discreta* Jones, × 20, showing the characteristic three pits of *Thlipsura*, one posterior and two anterior. Silurian, Island of Gotland. 6. Left valve of the genotype *Thlipsura corpulenta* Jones and Holl, × 20. Silurian, Woolhope, England.
7. *Phreatura* Jones and Kirkby. Right valve of the genotype, *Phreatura concinna* Jones and Kirkby, × 50. The shallow semi-circular pit at each end and the compressed posterior end are characteristic. Carboniferous, Yoredale, England.
8. *Craterellina* Ulrich and Bassler. Right valve of the genotype *Craterellina robusta* Ulrich and Bassler, × 20, showing the characteristic anterior crater-like depression. Devonian (Oriskany formation), Cash Valley, Maryland.

Genus OCTONARIA Jones

Similar to Thlipsura but distinguished by having the surface of the valves raised into a thin spiral or ring-like ridge which in the more typical forms resembles the figure 8.

Genotype.—Octonaria octoformis Jones. Ordovician, Devonian.

Genus PHREATURA Jones and Kirkby

Distinguished from Thlipsura by the strong compression of the posterior end of the shell; this end is further marked by a shallow though clearly outlined, semicircular pit; a similar though smaller pit at the anterior extremity.

Genotype.—Phreatura concinna Jones and Kirkby. Carboniferous.

Genus CRATERELLINA Ulrich and Bassler

Valves similar to Octonaria and Thlipsura but the anterior half or third is marked by a crater-like depression bordered by an elevated rim.

Genotype.—Craterellina robusta Ulrich and Bassler. Devonian.

Family BEECHERELLIDAE Ulrich

Small inequivalved, ovate, subtriangular or boat-shaped ostracoda having the posterior end of one or both valves drawn out into a spine. (Fig. 24.)

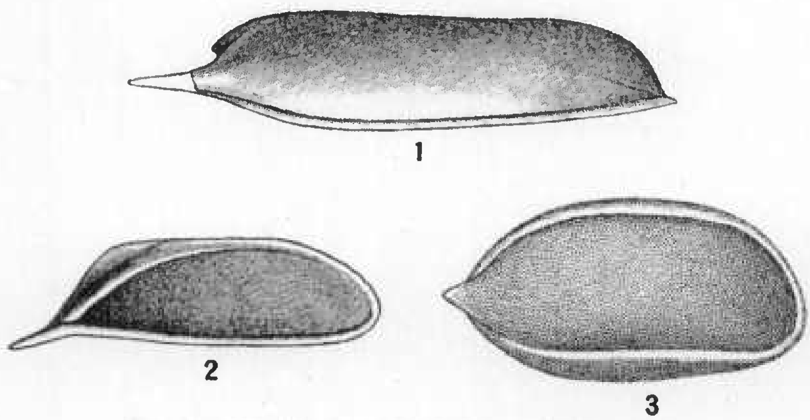

FIG. 24.—ILLUSTRATING THE FAMILY BEECHERELLIDÆ.

1. *Beecherella* Ulrich. A nearly perfect valve, × 20, of the genotype *Beecherella carinata* Ulrich. Helderbergian (New Scotland), Albany County, New York.
2. *Acanthoscapha* new genus. Interior view of valve of the genotype *Acanthoscapha (Beecherella) navicula* Ulrich, × 20, showing rounded instead of spinous anterior end and the formation of the posterior spine by a prolongation of the ventral edge. Helderbergian (New Scotland), Albany County, New York.
3. *Krausella* Ulrich. Right side of a complete carapace, × 20, of the genotype *Krausella inæqualis* Ulrich, showing the larger left valve, overlapping the right all around except at the acuminate posterior extension of the smaller valve. Ordovician (Black River) limestone of Illinois.

Genus BEECHERELLA Ulrich

Shell elongate, boat-shaped, triangular in cross section, the ventrum being flat and carinated on its outer edges; ventral carinæ prolonged at each end into spines, the anterior one short and small, the posterior much larger; hinge apparently simple while the ventral edge of the right valve seems to overlap the left sharply.

Genotype and Only Species.—Beecherella carinata Ulrich. Lower Devonian.

Genus ACANTHOSCAPHA new genus

Similar to Beecherella but the anterior end is spineless and rounded in outline while the posterior spine is formed by a prolongation of the ventral edge instead of the outer carina which may be wanting entirely. Within the posterodorsal region the true contact edge is set some distance within the outer edge of the valves.

Genotype.—Acanthoscapha (*Beecherella*) *navicula* Ulrich. Lower Devonian.

Genus KRAUSELLA Ulrich

Similar to Beecherella except that the valves are more unequal, the left overlapping the right both dorsally and ventrally while but a single spine occurs, this being a prolongation of the posterior extremity of the smaller (right) valve.

Genotype.—Krausella inæqualis Ulrich. Ordovician, Silurian.

Family BAIRDIIDAE new family

Minute, mostly reniform or elongate ovate, corneo-calcareous shells with thin, more or less unequal valves, one overlapping the other either ventrally or dorsally, or both.

This new family is instituted for the genera Bairdia McCoy, Bythocypris Brady, Pontocypris Sars, and Macrocypris Brady, the latter three based upon recent species. It is possible that future studies will show the Paleozoic representatives of these three genera to be distinct from their modern genotypes, but in any event these four genera are thought to be different from the fresh-water Cypridæ to which they have hitherto been referred. (Fig. 25.)

Genus BAIRDIA McCoy

Shell subtriangular or rhomboidal, with the greatest height near the middle, inequivalved, narrowly rounded anteriorly and more or less acuminate posteriorly, generally smooth; dorsal margin more or less strongly convex; hingement formed by strong overlap of the left valve over the right.

Genotype.—Bairdia curta McCoy, a Carboniferous species. Range Silurian to Recent, particularly abundant in the Carboniferous.

Genus BYTHOCYPRIS Brady

Shell smooth, reniform, ovate or elliptical; left valve larger than the right overlapping it usually on both the dorsal and ventral margins;

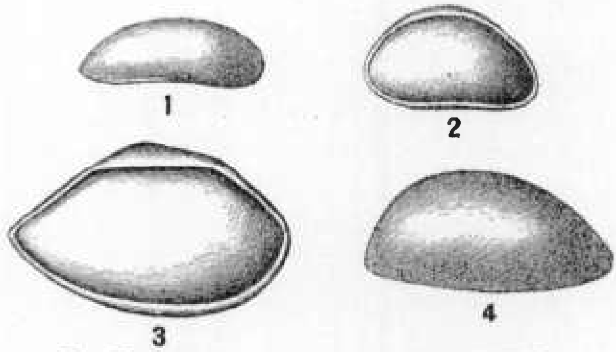

FIG. 25.—ILLUSTRATING THE FAMILY BAIRDIIDÆ.

1. *Macrocypris* Brady. Left valve of *Macrocypris vinei* Jones, × 15, showing elongate shape and acuminate posterior end. Silurian, Island of Gotland.
2. *Bythocypris* Brady. Complete carapace of *Bythocypris phillipsiana* Jones and Holl, magnified, illustrating form of shell and overlap of valves. Silurian of England.
3. *Bairdia* McCoy. Complete carapace of a typical Carboniferous species *Bairdia beedei* Ulrich and Bassler, × 30. Carboniferous of Kansas.
4. *Pontocypris* Sars. Valve of *Pontocypris mawii* Jones, × 30. Silurian, Island of Gotland.

dorsal margin convex, the ventral edge straighter, sometimes slightly concave.

Genotype.—Bythocypris reniformis Brady, a recent species. Range Ordovician to Recent.

Genus PONTOCYPRIS Sars

Similar to Bythocypris except that the shell is very delicate and the hinge simple without overlap.

Genotype.—Pontocypris serrulata Sars, a recent species. Range Silurian to Recent.

Genus MACROCYPRIS Brady

Similar to Bythocypris but as a rule more elongate, posteriorly more acuminate and with the right instead of the left valve the larger; inner side of valves with a thin plate along the anterior ventral and posterior edges.

Genotype.—Macrocypris minna Baird, a recent species. Range Ordovician to Recent.

Family CYPRIDAE Zenker[1]

Palæocypris Brongniart, Cypris Müller, Cypridea Bosquet, Aglaia Brady, Argillœcia Sars, Cypridopsis Brady, Potamocypris Brady, Paracypris Sars, Notodromus Sars, Candona Baird.

Family CYTHERELLIDAE Sars

*Cytherella Jones, *Cytherellina Jones and Holl, *Pachydomella Ulrich, Bosquetia Brady.

Family ENTOMIDAE Jones

*Entomis Jones, *Entomidella Jones, *Elpe Barrande.

Family CYPRIDINIDAE Sars

*Cypridina Milne Edwards, *Cypridinella Jones, Kirkby, and Brady; Cypridellina J. K. and B., *Cypridella DeKoninck, *Cyprella DeKoninck, *Sulcuna J. K. and B., *Rhombina J. K. and B., *Cyprosis Jones, *Cyprosina Jones, Bradycinetus Sars, Philomedes Lilljeborg, Eurypylus Brady, Asterope Fischer.

Family ENTOMOCONCHIDAE Ulrich

Entomoconchus McCoy, *Offa J. K. and B.

Family POLYCOPIDAE Sars

Polycope Sars.

[1] To complete the classification of the ostracoda we list only the following families, their study not having been undertaken at the present time. Genera marked * are Paleozoic or have Paleozoic representatives.

Family DARWINULIDAE Jones

Darwinula Jones.

Family BARYCHILINIDAE Ulrich

*Barychilina Ulrich.

Superfamily CYTHERACEA

Family CYTHERIDAE Zenker

Cythere Müller, Cythereis Jones, Cytheridea Bosquet, Cytherideis Jones, *Carbonia Jones, Cytheropteron Sars, Xestoleberis Sars, Pseudocythere Sars, Krithe Brady, Crosskey and Robertson; Eucythere Brady, Cytherura Sars, Sclerochilus Sars, Kiphichilus Sars, Limnicythere Brady, Sarsiella Brady, and Paradoxostoma Fischer.

OSTRACOD ZONES OF THE SILURIAN

INTRODUCTION

Although the Ostracoda, despite their usual minuteness, are interesting for themselves, the dominating purpose of their intensive investigation, mainly for the present work, lay in the hope that they might throw some very much needed light on Silurian stratigraphic problems.

Prior to 1916, study of other classes of fossils by the senior author, in connection with extensive field investigations of the beds containing them, had shown very clearly that a large part of the deposits in the Appalachian region—especially in its southern half—which had been classed as of the age of the Clinton were in fact older. Most of these pre-Clinton beds were shown to be of late Medinan age, others of early Medinan or Richmond and some of them even so old as late Ordovician—that is, Maysville and Eden.

In Alabama and Georgia it was found that whereas the supposed Clinton, or Rockwood, as it was more commonly called, actually is mainly made up of beds corresponding in age to the Clinton at the typical locality in New York, its basal part locally included also a band of similar iron-bearing strata that is of the age of the Brassfield of Kentucky and Ohio, which corresponds to the upper part of the Upper Medina in New York and the Cataract formation in Ontario. Its top, on the other hand, locally comprises beds that were regarded as Upper Clinton, and possibly as young as the Rochester shale. In Alabama, then, the sequence of Clinton deposits seemed essentially the same as at Clinton, N. Y., where the formation likewise was thought to include a considerable thickness of deposits of Rochester age. However, at least one important difference was recognized, namely, the Alabama Clinton does not include beds corresponding to those which come to the surface and make up the lower part of the formation in the area between the towns of Clinton and Utica in New York. The missing beds are the ones that contain the wealth of ostracod forms that up to the present time have been loosely referred to *Beyrichia lata*. Although Ostracoda were found in the shaly beds above the oölitic iron ore at Clinton, N. Y., none of them seemed strictly the same as those which are so exceedingly abundant in the mentioned more sandy lower beds in the town of New Hartford and at other nearby places in New York, and which are found hardly less abundant to the southward in the Clinton rocks of central Pennsylvania, Maryland, and Virginia. Very disappointing, too, was the fact that none of the New Hartford Ostracoda—now known to belong in the Mastigobolbina lata zone—nor indeed any kind of Ostracoda had ever been listed or, so far as known, ever been found in the Clinton section beneath the Rochester shale in the valley of Genesee River. Perhaps even more disturbing was the known occurrence of the New Hartford species in northwestern Georgia when the data in hand indicated the entire absence of the Clinton in the Appalachian valley region between the Georgia locality and the northern boundary of Tennessee.

How were these seeming inconsistencies and anomalies in faunal distribution to be explained? Were they to be ascribed to local variations in the composition of faunas, or to vertical shifting of species and faunas in migration, or to actual local absence of the beds themselves? The other classes of fossils helped very little in solving these questions, mainly perhaps because they were few in number, poorly preserved and too often wanting entirely where their need was greatest. Under the circumstances, the obvious primary essential was to enter the field with the data in hand and try to establish by careful collecting in the longest and best exposed sections the true sequence of the fossiliferous zones. Work to this end was planned and carried out by devoting parts of each of the past six seasons to the study of new and previously visited sections in New York, Pennsylvania, Maryland, Virginia, Georgia, and Alabama, and the collections from all of these places were prepared and minutely scrutinized. Incidentally, fine collections of Ostracoda were procured from localities and beds in New York and elsewhere that had previously been thought to be without them. As a result most of the perplexities have been cleared so that we can now present conclusions with a reasonable degree of confidence. However, most of the stratigraphic details are reserved for a special work on the Medina and Clinton formations in eastern North America. Here only such parts will be given as may be required to fix the Clinton correlations.

THE CLINTON GROUP

Under the term Clinton group is embraced all the beds in New York lying between the base of the Arthophycus bearing basal sandstone, generally known as the "Gray Band," and the top of the Rochester shale. It constitutes the lower group of the Niagaran series, the upper group being the Lockport group of which the Guelph dolomite is the top member or formation. The Clinton group in New York is divisible into three main parts, having the rank of formations, which for present purposes may be conveniently designated as Lower Clinton, Middle Clinton, and Upper Clinton.[1] Each of these three Clinton formations, except perhaps the middle one, is again divisible into two or more lithological members for most of which names have been proposed by Hartnagel[2] and more recently

[1] More formal locality names will be proposed for these formations in a work on the Silurian formations in New York, in the preparation of which the senior author of the present memoir is cooperating with Dr. Rudolph Ruedemann and Mr. C. A. Hartnagel.

[2] Hartnagel, C. A., 1907, Geologic map of the Rochester quadrangle.

by Chadwick.[1] The three major divisions of the Clinton are distinguished by strongly marked faunal differences which are maintained and clearly recognizable from New York to Alabama. They differ also very decidedly in geographic distribution.

Clinton Section at Rochester, N. Y.

In order that the character and relations of the subdivisions of the Clinton in New York may be clearly understood it is thought essential to give at least two local sections in considerable detail. The first of these describes the beds as exposed in the gorge of Genesee River at Rochester. The other section, which is at Clinton, the type locality, is postponed to later pages that deal particularly with the Upper Clinton division in New York. Both of these sections are taken from notes made by the senior author in 1913.

SECTION OF THE CLINTON GROUP AT ROCHESTER, N. Y.

	Feet
Niagaran series	
Lockport group	
Ordinary Lockport dolomite with the hydraulic De Cew limestone member at base and resting unconformably on the Rochester. Section incomplete at top, present about	125

[1] Chadwick, G. H., 1918, Stratigraphy of New York Clinton, Bull. Geol. Soc. Am., 29, pp. 327-368. This work by Chadwick, despite the obvious fact that it is based more on the literature than upon independent field investigation, is an important contribution to the subject. It departs in many respects widely and in part properly from preceding conceptions, but is still unduly influenced by the old belief in the eustatic nature of the emergences and submergences of the land areas. It fails particularly in disregarding the probability of differential factors in the movement of the lithosphere at times of sea withdrawal and readvance and which would have produced unequal warping of the surface and corresponding irregularities in the migration of the strandline. Besides, the author did not know that the fossils, especially the Ostracoda, of some of the beds correlated by him are in fact definitely indicative of distinct zones whose stratigraphic relations have been established. In view of these facts it is not surprising that Chadwick made the mistake of correlating two entirely distinct Lower Clinton ostracod zones with the Middle Clinton Mastigobolbina lata zone, and following this correlates Upper Clinton beds in Herkimer County with Lower Clinton beds at Rochester. For these and other reasons Chadwick's new nomenclature of the Clinton rocks in New York, while correcting some real errors in preceding practice, nevertheless complicates the subject greatly and introduces new perplexities.

	Feet
Clinton group	
Upper Clinton	
Rochester shale	
Interbedded limestone and shale, highly fossiliferous...	85
Irondequoit limestone	
Thin limestone interbedded with considerable shale in lower half, the shale becoming less in upper half. At top often with reefy elevations that project into the otherwise even base of the Rochester shale, which followed without time break........................	18
The faunas of the Irondequoit limestone and the Rochester shale are much alike and both of predominantly southern origin. However, species and genera of Atlantic origin, particularly Ostracoda, occur in both.	
Williamson shale	
Shale, dark colored, with *Monograptus clintonensis* and *Rastrites venosus*	6
Stratigraphic break (Middle Clinton and Wolcott limestone and Sodus shale of Lower Clinton and lower part of Williamson shale missing).	
Lower Clinton	
"Bear Creek shale"	
Shale, olive above purple below, with intercalated layers of "pearly" limestone, full of *Anoplotheca* (*Cœlospira*) *hemispherica* and Ostracoda of the genus Zygobolba which is here represented by five species, all of which are characteristic of the *Z. anticostiensis* zone........	18
Upper "Reynales limestone"	
Limestone, the middle and upper parts magnesian, the lower 15 inches nearly pure and full of *Pentamerus oblongus*. Upper 8-12 inches with shells of a species of Brachioprion very abundant, the middle part with fewer fossils	4-5
Limestone, magnesian, bluish, sparingly fossiliferous, the lower third with chert. Fossils essentially as in underlying layer	7-8
Limestone, thin bedded, the top inch or two very fossiliferous, with *Camarotœchia* sp., *Anoplotheca hemispherica*, *Stricklandinia canadensis* and a few undetermined Bryozoa	0.6
Limestone, magnesian, the upper half (8 inches) with chert and carrying on its uneven top surface the same kinds of shells as in overlying layer; beneath this two 4-inch layers without chert and nearly unfossiliferous.	1.3
Shale and two or three layers of magnesian limestone, 17-24 inches	2

	Feet
Typical "Reynales limestone"	
Furnaceville iron ore, 6-11 inches thick, two broadly wave-marked, the ripples striking N. 15° E. and 30 to 50 inches from crest to crest. Upper surface with a Chondrites-like fucoid, the branches about one-sixteenth inch wide and dividing mainly in pinnate manner. The bed itself is largely made up of broken organic remains and quartz grains all coated with iron. The fossils so far as determined are of species occurring in the underlying limestone....................	1
Thin limestones and shale, the limestone layers becoming thinner and farther separated downward so that the bed grades without break into the underlying shale. About 2 feet 8 inches beneath the top a limy layer with black (? phosphatic) pebbles and minute gastropods (Cyclora and Microceras). The upper half of bed contains a fair representation of the *Hyattidina congesta* or typical Reynales Basin fauna............	3-4
Maplewood shale	
Shale, soft, green, unfossiliferous, the base sharply defined from the underlying sandstone................	14-21
Thorold sandstone ("Gray band")	
Massive, hard, impure, light gray sandstone, with a small form of *Dædalus archimedes*......................	3-5
Age uncertain (? Late Medinan)[1]	
Sandstone, muddy, red, partly thick-bedded, mottled with shale pebbles, and containing both the larger and smaller forms of *Dædalus archimedes*................	12-14
Sandstone wedge, its upper part with *Arthrophycus alleghaniense*, its lower part showing "pillow structure" and containing *Dædalus archimedes*................	1-7

[1] The age of the four beds of sandstone beneath the Thorold sandstone in this section is in doubt. Hitherto they, together with the Thorold, have been referred without reservation to the Medina. But this assignment was made mainly on the mistaken belief that *Arthrophycus alleghaniense* is confined to rocks of that age. On the contrary most, if not all, of the occurrences of this peculiar fossil are in younger beds than those at Medina and Lockport that contain the typical marine fauna of the Upper Medina. The Arthrophycus and Dædalus borings seem never to occur in association with the unquestioned marine shells. They are always found above the shells. Still this fact does not establish that all of these borings are of subsequent time. Some of them may yet prove to be contemporaries of the Upper Medina marine fossils. The animals that made the borings probably lived in tbe muddy sands of beaches on bodies of fresh and brackish waters. Being therefore essentially land, or rather nonmarine, animals the withdrawal of the epicontinental seas obviously had a less unfavorable effect on the continuity of their existence than on the

	Feet
Sandstone, rather regularly thin-bedded, red, with occasional thin shale partings; contains *Dædalus archimedes* and in its upper half casts of Arthrophycus-like borings, but these lack the characteristic annulations.	20
Basal sandstone, heavy bedded, reddish or chocolate colored, quartzose, conglomeratic; pebbles consist of quartz, chert, sandstone, clay, red shale, ranging in size from very small to 6 inches. Base unconformable.	4-10
Medinan	
(Upper Medina wanting?)	
Queenston shale, exposed	40

The Lower Clinton in New York

In western New York the Lower Clinton begins with the Thorold sandstone (" Gray Band ") which hitherto has been generally regarded as the highest zone of the Medina. In fact, however, it really constitutes either the top member or the whole of the more or less coarsely clastic initial deposit of the Clinton over the eroded and unconformable top of the underlying formation. At Niagara Falls it rests on mostly red sandstones that may be safely correlated with the closing marine stage of the Medinan series. Between Lockport and Rochester it lies on various older sandstones of the Upper Medina. East of Rochester the surface on which the Arthrophycus zone rests drops more and more in the section until at or to the east of Utica it lies on the Ordovician Frankfort shale. In the meantime, too, the Arthophycus zone has risen, first to the base of the

strictly marine organisms which were exterminated at least locally on the withdrawal of their natural habitat. For the same reason, too, these sand burrowing animals could very well appear not only in the initial advancing beach deposits which range through the Lower and Middle into even Upper Clinton ages, but they might also have been living and taking advantage of conditions favoring their existence that are easily conceivable as having occurred during the shallowing and filling of the preceding late Medina sea. Accordingly then these questioned sandstones in the Rochester section may very well be interpreted as late Medina beach deposits that were seldom if ever before Clinton time sufficiently submerged to permit the existence here of the marine fauna of the time. Under this conception, too, *Arthrophycus alleghaniense*, and for the earlier parts of the concerned time also *Dædalus archimedes*, lose their commonly assumed indexical value as late Medinan guide fossils and become remains of land organisms that persisted to at least the closing stage of the Clinton.

Middle Clinton and finally to the base of the Upper Clinton. To make the case plainer we may add that the Arthophycus zone is the tangential base of the Clinton, passing on the west into the Gray Band and then into the essentially equivalent Thorold sandstone and on the east into the typical Oneida conglomerate. The greater the stratigraphic break at its base—with due regard, however, to the nearness of the compared localities to respectively the eastern, northern, and northwestern shores of the composite Clinton sea and also the probable relief and nature of the adjacent contributing lands—the thicker and usually the coarser is this clastic basal deposit.

The next oldest bed of the Clinton as developed in New York is a green unfossiliferous shale, best displayed in the section at Rochester where it is 21 feet in thickness. This bed was formerly called Sodus shale, but Chadwick, having shown that the Sodus shale at the type locality is a younger bed, has proposed to designate it by the new name Maplewood shale. In our opinion this shale pinches out somewhere between Lakeport and Verona and does not, as Chadwick thinks, reappear in greater thickness to the east of Verona. The obvious error in the latter view is that it postulates the almost inconceivable condition of absence of the Lower Clinton Maplewood shale in the thickest known development of the Clinton under Lockport and recognizes its presence in even greater volume in the shallower section under Clinton. In other words, it recognizes the presence of a shale formation on the opposite rising flanks of a basin and has it wanting in the deeper middle part.

Above the Maplewood shale, in the section at Rochester, is a tripartite limestone about 18 feet thick. The lower 4 feet, which contains a representative of the Furnaceville iron ore seam, is definitely recognized by its fossils in all exposures of this horizon to the west as far as Hamilton, Ontario. Eastward from Rochester the limestone part of this lower member passes into and is soon completely replaced by the expanding Furnaceville ore bed. The latter continues on to the vicinity of Martville, beyond which it either pinches out or passes into shale. The upper 5 feet contain some nearly pure limestone layers and these are filled with a form of *Pentamerus oblongus*. This large shell is wanting to the west of Rochester, and it seems probable the layers that contain it there are not represented in the sections at Lockport and Niagara Falls. To the east of Rochester the Pentamerus continues in the section for some 40 or 50 miles but is unknown beyond the town of Wolcott. The middle member is the more highly magnesian and the most persistent of the three zones. However, it appears to be generally wanting in the outcrops of the formation between Lockport and Albion, in which stretch, as at Reynales Basin, near Gasport, and at Mellina, only the lower member has been observed. Apparently it attains its maximum thickness of 11 feet at Rochester, is 9 or 10 feet thick at Niagara Falls, and in the opposite direction pinches out entirely at some place beyond Lakeport. The bed is everywhere only sparingly fossiliferous and so far as known contains only one species that is particularly characteristic of it. This is the *Stricklandinia canadensis.* Besides this the bed is notable for the first appearance of *Anoplotheca hemispherica,* which was found with the Stricklandinia in the shaly lower part at Rochester.

This tripartite limestone was identified by Hall and later by Hartnagel with the Wolcott limestone, mainly because both contain *Pentamerus oblongus.* But, as is well known now, the typical Wolcott limestone is a higher bed which does not extend westward to Rochester. Chadwick therefore proposes the name Reynales limestone for it.[1] The lower member contains a considerable and for the most part highly characteristic fauna, differing rather widely from that of the typical Wolcott and reminding, particularly in its bryozoan elements, rather more of certain Brassfield and Cataract faunas than of succeeding Clinton faunas.

[1] In proposing the term Reynales limestone Chadwick recognizes the fact that one "must go to Lockport or the Rochester gorge for the typical section. As only the lower member is present at Reynales Basin the question is raised whether it is either wise or permissible to employ this term for the whole formation rather than for the lower member alone. Some special designation is desirable for the lower member. It is easily distinguished by its fauna and as most of its known fossils were originally collected in the vicinity of Reynales Basin it seems eminently proper to restrict this name to the beds occurring at Reynales instead of using it in the broader sense advocated by Chadwick. Pending the selection of a more appropriate name for the formation as a whole "Reynales limestone" is adopted provisionally.

THE BEAR CREEK AND SODUS SHALES.—The main difficulties in the interpretation of the New York Clinton sections come in above the Reynales limestone. In the section at Rochester this limestone is succeeded by an 18-foot bed of purple and olive shale with thin plates of fossiliferous pearly limestone. The pearly lustre is owing mainly to the shells of *Anoplotheca hemispherica* (Hall, Murchison?), which are exceedingly abundant. With these and also in the shale itself often occur a number of fairly characteristic Pelecypoda, *Phacopidella trisulcata,* and well-preserved valves of Ostracoda of which the most important are five species of the genus Zygobolba. Because of their bearing on correlations with formations in the Island of Anticosti and with Clinton zones in Maryland and Virginia discussion of these Ostracoda and the species of Anoplotheca, both of which are characteristic of this zone and widely distributed, is deferred to the chapter on correlation.

This particular bed of shale has received no name that is strictly applicable to it unless it be Chadwick's term Bear Creek shale. Hartnagel included it with the overlying dark graptolitiferous shale in his Williamson shale. But the true Williamson shale overlies the true Wolcott limestone which is absent in the Rochester section. Moreover, the Wolcott is underlain by another shale, the true Sodus, which also is younger than the shale at Rochester here under discussion and like the Wolcott limestone is wanting there. Evidently, then, there must be a stratigraphic break in the Rochester section between the dark, true Williamson and the underlying olive and purple shale here referred to. Chadwick, on the other hand, unites it with the similar Sodus shale which, as will be shown presently, contains a younger and quite different fauna. Chadwick's Bear Creek shale—which he says lies "just *beneath* the Furnaceville ore," but which according to Hartnagel lies not only over that ore but also over the Reynales limestone that separates the two—contains the pelecypod fauna that occurs in this shale at Rochester and probably in the same bed. In the absence of an unquestionable geographic name the bed is herein designated the *Zygobolba anticostiensis* zone.

As shown in the section and mentioned in the preceding paragraph, the *Z. anticostiensis* zone is succeeded at Rochester by 5 or 6 feet of dark shale containing an abundance of *Monograptus clintonensis*. The hiatus between these two shales is occupied in the vicinities of Sodus and Wolcott by (1) a thin limestone followed by a few inches of iron ore (Sterling Station iron ore of Chadwick), (2) 55 feet or more of Sodus shale, (3) Upper Pentamerus or typical Wolcott limestone, 22 feet, and (4) the Wolcott Furnace ore bed. These four lenses constitute the remaining upper members of the Lower Clinton. The Williamson shale which rests on the Wolcott Furnace ore bed in Wayne County is regarded as the basal member of the Upper Clinton. Wedging in from the east between the base of the Upper Clinton and the top of the eastwardly attenuating Lower Clinton is a lenticular mass that we are calling Middle Clinton. East of Clinton this intervening mass lies for a time at the base of the Clinton but its eastern edge is finally overlapped by the Upper Clinton so that in the eastern part of Herkimer County the latter, together with the initial deposit of Oneida conglomerate, constitutes the whole of the Clinton group as there developed.

Regarding the thin limestone and ore at Sterling Station little is known beyond the fact that it lies between the *Z. anticostiensis* zone (Bear Creek shale) and the overlying Sodus shale. We may add that it probably represents the sedimentary record of the retreat of the sea in which the *Z. anticostiensis* zone was deposited.

The succeeding Sodus shale, like the *Z. anticostiensis* zone at Rochester, consists mainly of purple shale with thin layers of highly fossiliferous pearly limestone. The general aspect of the faunas of these two shale beds also is much the same. However, on critical comparison, the simulating fossils prove in most cases to be distinguishable. There are two species of Anoplotheca in the Sodus, one with a short hinge and rounded outline, the other long-hinged like *A. hemispherica;* but neither is strictly the same as the one found at Rochester. The Ostracoda also are different, the differences being notable particularly in the lobate forms of the genus Zygobolba of which four species are recognized. Because of the immediate need of evidence showing the distinctness of these two purple shales we may anticipate matters to be discussed in the correlation chapter by saying that the four species of Zygobolba in the typical Sodus shale are found also on the Island of Anticosti where they occur only in the Jupiter River formation. On the other hand, the five species of Zygobolba which are found in the shale at Rochester clearly represent a lower zone in the Anticosti section, four of the five species being confined there to the underlying Gun River formation.

THE WOLCOTT LIMESTONE.—For reasons stated with sufficient clearness by Chadwick (*op. cit.*, p. 347) the term Wolcott limestone, which had previously been used so loosely that it included the lower Pentamerus-bearing Reynales limestone of the Rochester section, is restricted to the "Upper Pentamerus" limestone, the typical outcrop of which occurs on small creeks near Wolcott village. In this vicinity the Wolcott limestone apparently attains its maximum thickness of 22 feet. To the west it pinches out rapidly, being much thinner at Williamson and entirely absent in the Rochester section. It thins less rapidly, though taking on a shaly character, also in an easterly direction but evidently fails entirely before reaching Clinton. Chadwick correlated this limestone with the calcareous "shales above the oolitic ore at Clinton" (*loc. cit.*), but the physical and faunal evidence in hand is so uniformly and strongly at variance with this view that we feel obliged to set it aside as erroneous.

Some twenty species of fossils from the Wolcott limestone, procured by the writer mainly from an outcrop on Second Creek, near Alton, New York, show that the fauna of this formation is totally different from that of the underlying Sodus shale. The Sodus fauna is a typical Atlantic Silurian association, in this case consisting of little besides a considerable variety of Ostracoda and the two species of Anoplotheca. The Wolcott limestone fauna, on the contrary, has no Ostracoda, lacks also the Anoplotheeas, and is made up mainly of types of Bryozoa and Brachiopoda that occur elsewhere in America only in faunas that invaded the continent from the south. The Bryozoa comprise about half of the fauna and these particularly remind of species that appear first in the Brassfield-Cataract zone of the Medinan and reappear, with slight though usually distinguishable modifications and more striking loss or gain of temporarily characteristic species, in the Reynales limestone near the base of the Clinton, again in the Wolcott limestone, next in the Rochester shale at the top of the Clinton, and finally in the Waldron shale of the Upper Niagaran. Regarding their occurrence in the Wolcott limestone close comparison with the other appearances of the fauna shows that the Trepostomata, the Chasmatopora and the broadly frondescent Phaenoporas which characterize the older occurrences are now lacking leaving only the Fenestellidae and other Cryptostomata that are known to pass on into the Rochester age. But the host of other Bryozoa that distinguishes that later stage from the preceding facies is still lacking.

None of these Bryozoa nor any of the other types of fossils that usually are associated with them ever occur in the Silurian faunas that invaded the continent from the east. When one of these eastern faunas is directly succeeded by one of southern origin the differences between the two usually are very striking. Yet these apparently great breaks in the faunal sequence commonly do not signify long lapses of time during which the character of a fauna might be expected to change greatly through ordinary processes of evolution. In most cases, as is surely so of these Clinton breaks, they mean only changes in the direction of supply. In this manner we account for the absence in the Appalachian region of Maryland and adjoining States of many species and often whole faunas that occur in nearly synchronous deposits in more interior parts of the continent.

The Lower Clinton in Northwestern Ontario

The ostracod fauna of the Dyer Bay dolomite of Ontario proved so interesting in the present study that the following paragraphs were believed appropriate. The Dyer Bay dolomite was originally referred by Williams to the base of the Lockport, but in his final work [1] on the concerned formations he classifies it as a part of the Cabot Head shale which he regards as representing the greater part of the Upper Medina or Cataract formation in northwestern Ontario. As the Dyer Bay dolomite contains the brachiopod *Virgiana mayvillensis*, Williams correlates the Dyer Bay with the Mayville dolomite of the Silurian section in eastern Wisconsin.

[1] Williams, M. Y., The Silurian Geology and Faunas of Ontario Peninsula and Manitoulin and adjacent islands: Canada Dept. of Mines, Memoir 111, No. 91, Geological Series, 1919, p. 36.

In our opinion this reference of these dolomitic limestones to the Medinan is unwarranted. The problem is complicated and its full discussion is reserved for another occasion. It is mentioned here mainly because specimens of three of the Ostracoda described and illustrated in this volume come from the typical locality of the Dyer Bay dolomite and the desirability of some explanation for our reference of these species to a higher position in the time scale than that given them by Williams. Briefly, the evidence in the case is as follows: The senior author has collected more than 100 species of fossils from the Mayville dolomite near Mayville, Wis. These fossils certainly are neither of "Alexandrian" age, as Savage[1] classifies the formation, nor of the age of the Cataract or Upper Medina as Williams has it. They are Niagaran and probably represent some part of the Clinton, whether Lower, Middle or Upper Clinton need not be decided at present. The Dyer Bay dolomite being, as is generally admitted, of the age of the Mayville must therefore also be of Niagaran and not Medinan age. Confirmation of this conclusion is found in the Dyer Bay Ostracoda that were studied by us for Doctor Williams and partially listed by him under the preliminary names then applied to them (*op. cit.*, p. 37). In all, six species were distinguished: *Chilobolbina billingsi, C. punctata, Zygobolba williamsi,* two species of *Leperditia,* neither of which has yet been described, and a species of *Bythocypris* that has no particular stratigraphic significance. The two species of Chilobolbina occur in both the Gun River and Jupiter River formations in Anticosti; and the longer of the two species of *Leperditia* is found above the middle of the Gun River formation at Hannah Cliff. Varieties of both of the Chilobolbinas occur in the Mastigobolbina lata zone at Cumberland, Md.

As shown on preceding pages the Gun River and Jupiter River formations are of Lower Clinton age; and the Mastigobolbina lata zone is the most typical and persistent part of the Middle Clinton. According to this ostracod evidence, then, it appears that the Dyer Bay dolomite corresponds to the latter part of the Lower Clinton or the early part of the Middle

[1] Savage, T. A., Alexandrian rocks of northeastern Illinois and eastern Wisconsin: Bull. Geol. Soc. America, vol. xxvii, p. 310, 1916.

Clinton, with the former interpretation the more likely of the two. With the exception of the species collected on Fitzwilliam Island and referred by Williams to the Dyer Bay dolomite there is nothing in the remainder of the fossils of this bed as listed by him that would not look as well or better in a Clinton fauna than a Medinan one. Indeed, where else does one see corals like *Syringopora retiformis, Favosites cristatus,* and *F. obliquus,* or brachiopods like *Strophonella striata,* and *Rhynchonella bidens,* or a pelecypod like *Pterinea undata* or a trilobite of the genus *Liocalymene* (*Calymene cf. clintoni*), in rocks of pre-Clinton age? And how are we to explain that of the 10 fossiliferous Dyer Bay exposures given in Williams' tabulated list of fossils the so-called "Alexandrian" species occur only in the column of Fitzwilliam Island? Of the six fossils listed from this island only one (*Virgiana mayvillensis*) is noted as occurring in another of the 10 localities. The suggested possibility that the supposed Dyer Bay dolomite on Fitzwilliam Island is really an older bed should have been considered before Williams changed his belief regarding the post-Medina age of the Dyer Bay dolomite.

Just how this Clinton fauna got into the Michigan Basin is not easily explained. The Liocalymene and the Ostracoda at least, and less certainly also some of the Brachiopoda, doubtless are Atlantic types. But we see no possible chance of deriving them by direct migration from the Appalachian region across the Ohio Valley to the Great Lakes region. The only paths that now are suggested as probable are to the north from Lake Huron to Hudson Bay or in a more easterly direction across Quebec to the Gulf of St. Lawrence. Some definite basis for the belief that the Dyer Bay Ostracoda actually invaded the Great Lakes region from the northeast has come to us through a few slabs of fossiliferous limestone collected on the southeast branch of Blanch River north of Cobalt, Ontario. One of these pieces of limestone contains the *Leperditia* and *Chilobolbina punctata* which the Dyer Bay holds in common with the Gun River formation of Anticosti, and with them the *Zygobolba williamsi* which is so far known only from Ontario.

The facts in the case as above outlined may be summed up by saying that the trend of all the evidence—physical and stratigraphical as well as the purely faunal—now available is unqualifiedly opposed to the reference of the Dyer Bay dolomite of the Lake Huron region and also the in part contemporaneous Mayville dolomite in eastern Wisconsin to a pre-Niagaran age. The Mayville and Dyer Bay dolomites probably belong in the lower half of the Clinton group, but they certainly are neither "Alexandrian" nor Medinan in age.

The Middle Clinton in New York

The scene of the Clinton sequence is now shifted to the east where—between Clinton and New Hartford—the Middle Clinton is imperfectly exposed at a number of places along the sinuous outcrop of the formation. The recognition of the Middle Clinton in New York is based mainly on fossil evidence. Its top is rather satisfactorily indicated at the base of the oolitic iron ore at Clinton. However, the base of the Middle Clinton in this region is somewhat doubtful. It may extend down to and include the Oneida conglomerate and thus comprise all of the 125 feet or more of Clinton shale and sandstone that is known to underlie the oolitic ore at Clinton; or the basal part of this 125-foot interval may contain a thinned representation of one or more of the Lower Clinton beds. At present this question cannot be decided, but in the meantime the absence of any evidence whatever to the contrary warrants our assumption that at least the greater part of the doubtful interval is of Middle and not Lower Clinton age. In other words, that the Lower Clinton either has already pinched out beneath the town of Clinton or that the complete failure of the Lower Clinton is deferred to some place to the east of Clinton, in which case the section here would still retain some reduced and as yet unrecognized part or parts of the Lower Clinton.

NOMENCLATURE.—The matter of a geographic name for the Middle Clinton of New York is in doubt. In a paper read by the senior author before the Geological Society of America in 1917 the term Kirkland was used for it. At the same meeting Chadwick's paper on the Stratigraphy of the New York Clinton was read by title. The publication of the latter in the following year shows that its author proposes the term Sauquoit beds for the 125-foot interval between the base of the oolitic iron ore bed at Clinton and the underlying Oneida conglomerate. Chadwick's name Sauquoit may then be the one that will finally be adopted, but for reasons given in the preceding paragraph it seems unwise to take a definite stand on the point before certain features of the problem shall have been tested in the field. In the meantime the less definite term Middle Clinton will serve immediate purposes very well.

FAUNAL EVIDENCE.—As stated above the recognition of the Middle Clinton in New York is based mainly on fossil evidence. We know, for instance, that the sandstones and sandy shales which outcrop in the vicinity of New Hartford, in Oneida County, and which distinctly underlie the horizon of the oolitic iron ore bed at Clinton, contain an abundant and characteristic fauna of which the Ostracoda constitute the more important element. We know also that this fauna has not been observed in any of the Clinton beds found to the west of Oneida County nor in the beds which overlie the base of the oolitic iron ore in Oneida County. Finally, we know that this fauna is widely distributed in the Appalachian Valley and that it there overlies the zone that contains the characteristic Ostracoda of the Sodus shale of New York and the Jupiter River formation in Anticosti and underlies, as it does also at Clinton, N. Y., the Upper Clinton Bonnemaia rudis and Mastigobolbina typus zones. These stratigraphic relations have been definitely established in central Pennsylvania, at Cumberland, Md., and at localities in southwestern Virginia. Moreover, its absolute distinctness from Lower and Upper Clinton zones is established by the fact that near Armuchee, Ga., the Clinton group is represented apparently solely by that part of the group of which the Mastigobolbina lata fauna is particularly characteristic. With facts like these we can do no other than regard the Middle Clinton in New York as a deposit that is geographically limited in east-west direction and laid down in a special minor trough which we may view as the northern extremity of an arm of the larger depression in which the Clinton deposits of the Appalachian Valley were deposited.

It is true that the *Mastigobolbina lata,* the most characteristic of the Middle Clinton fossils, has been cited by geologists up to the publication of Chadwick's paper in 1918 as occurring in such other zones of the New

York Clinton as the " upper shale " at Rochester, the true Sodus shale, and the calcareous shale which overlies the oolitic iron ore at Clinton, but in all of these instances the identification of this species is erroneous. The Ostracoda found at Rochester are not of this species nor of any other that is found with it at New Hartford, but they belong to species of another genus, Zygobolba, that are characteristic of their own zone. Those in the Sodus shale also belong to Zygobolba but to other species of the genus that also are confined to a particular zone of their own. Essentially the same is to be said of the Ostracoda in the shale above the ore at Clinton. These belong to Plethobolbina, Bonnemaia and to large species of Mastigobolbina which are quite different from the *M. lata, M. vanuxemi, M. clarkei* and such other common and widely distributed Middle Clinton species as *Zygobolbina conradi.* The species found above the oolitic ore at Clinton indubitably mark their own zone which is recognized by the same association of forms from central Pennsylvania to southwestern Virginia and thence through Kentucky to south-central Ohio.

In New York the Middle Clinton contains other fossils besides the Ostracoda. But these seldom are abundant and well preserved and not many kinds have been found. However, in southern Pennsylvania and northwestern Georgia, a few localities are known where the member, especially its lower third, contains many fairly good brachiopods and pelecypods. Some of these may prove valuable for correlation purposes but need more detailed investigation before much use can be made of them. In any event their occurrence is too sporadic to permit them to rival their ubiquitous ostracod associates as guide fossils.

The Upper Clinton in New York

Under this provisional designation we include all the beds between the base of the true Williamson shale and the top of the Rochester shale, the proposed Gates limestone of Chadwick at the top of the Rochester being in doubt. The decided faunal break between the Middle and Upper Clinton in New York has long been recognized. It is manifested also very clearly in the Clinton sections of the Appalachian Valley from central Pennsylvania to the southwestern extremity of Virginia. The importance of the break in the latter region, though involving smaller numbers of species, is more truly indicative of actual change in the marine life of contributing oceanic basins than appears in comparing the several faunas of the Clinton in New York west of Clinton. Namely, in the Clinton faunas of the Appalachian Valley we are dealing almost exclusively with periodic incursions of the Atlantic fauna whereas in the Clinton faunal sequence of New York the pure Atlantic incursions that pertain to the Zygobolba anticostiensis zone (Bear Creek shale), the Sodus shale, the Williamson shale, and the Mastigobolbina typus or Paleocyclus rotuloides zone alternate with the strictly southern invasions that make up the whole of the Reynales and Wolcott faunas and over 90 per cent of the Rochester fauna as developed at Rochester and Lockport. Incidentally, we may mention that facts like these, referring particularly to the source of faunal supply, have an important, though almost universally neglected bearing on questions of correlation of formations and their classification into groups.[1]

COASTAL WARPING AND FAUNAL INVASIONS.—The Upper Clinton is distinguished from the Middle and Lower Clinton also in its geographic distribution and by crustal warping that caused the changes in geographic

[1] This remark is suggested by Chadwick's proposal to divide the pre-Lockport Silurian, which he calls "Eontaric or Anticostian" into two groups. The "Lower Eontaric" comprises the upper part of the Medinan series and the Lower and Middle Clinton, beginning with the Whirlpool sandstone and ending with the Wolcott Furnace iron ore bed on the top of the Wolcott limestone, the "Upper Eontaric" beginning with the Williamson shale and ending with the Gates limestone which lies on the Rochester shale and thus corresponding very nearly with our Upper Clinton. In our opinion the most commendable feature of this proposed classification is the recognition of the alliance of the Rochester shale with the underlying Irondequoit limestone and the Williamson shale rather than with the overlying Lockport dolomite. As for the remaining innovations we can say only that they do not fit the conditions required in the Appalachian region and that our study of the Clinton and Medina formations in New York and Ontario tends without exception to show the absolute invalidity of the arguments presented by Chadwick in proposing them. This statement is quite apart from certain errors in the sequence and correlation of some of the stratigraphic units and also the fact that Chadwick failed entirely to observe the distinctness of what is here called Middle Clinton. Chadwick's otherwise praiseworthy effort in this case is merely another good illustration of the danger of introducing important changes in the classification of formations without adequate field and laboratory data and experience wide enough to include all the concerned areas.

patterns. In areal extent the Upper Clinton greatly exceeds the preceding divisions of the group. Though relatively local oscillations are suggested by irregularities in the distribution of certain of the Upper Clinton faunas there is still abundant evidence to show that deposits with fossils indicating more or less clearly certain middle and later stages of this time occur to the northeast as far as Littleton, N. H., and to the west in southern Ohio. Both of these extensions of the normal Clinton marine area of deposition are of the Mastigobolbina typus zone, which carries a purely Atlantic fauna; but no preceding Atlantic Clinton fauna is known in either of these outlying places and only one later extends by a different path so far west from the Appalachian Valley as Ohio.

As previously remarked the southern fauna repeatedly invaded and alternated with the Atlantic fauna in occupying the Clinton area of western and central New York. Both the Reynales and the Wolcott limestone faunas are of southern origin and they remain uncontaminated to their easternmost extent. Evidently these invasions were either separated by some land barrier from the Appalachian Valley sea of the time or the latter trough was not submerged at their times. The Rochester shale fauna, on the contrary, does show contamination and mixture of Atlantic and southern faunas so that we cannot readily escape the conviction that the barrier which had kept the preceding faunas apart was now at least less effective.

ROCHESTER FAUNA.—The fauna of the Rochester shale in western New York, where its fossils have been collected assiduously through nearly a century, comprises approximately 235 species. Nearly a third of this large number consists of Bryozoa, every one of which suggests only a southern origin. In other words, the Rochester Bryozoa are without exception more or less closely allied to older or younger genera and species in western and southern formations—the Waldron shale, Osgood limestone and Brassfield-Cataract formations—whose faunas are confidently viewed as invading from the south. In tracing the Rochester horizon eastward from its typical locality its fauna becomes rapidly less, so that diligent search of the formation at localities in Wayne County, at which the Rochester yet maintains its typical lithological facies, failed to reveal more than a fifth of the species found in this formation 40 to 50 miles west. At Clinton nearly all that is left of the remarkably prolific southern Rochester fauna consists of about a dozen of its Bryozoa which occur there in fragmentary though still recognizable condition in the upper or red flux ore bed.

Accordingly, then, we infer that the southeastward tilt of the Appalachian land which had made possible the invasion of northwestern Georgia by an Atlantic Middle Clinton fauna was reversed in direction so that the Georgia locality was emerged whereas the wide area between the Adirondacks and central Kentucky was subjected to Atlantic submergence through a more northern inlet.

The exceedingly few (two or three fragments of) Bryozoa that have been observed in the Appalachian Clinton deposits north of Alabama occur in the M. typus zone of the Upper Clinton. Only one of these specimens is specifically determinable, and this is referred to *Phylloporina asperatostriata,* a characteristic Rochester species. Whether this is a venturesome straggler of the southern host or whether this species ranged also in the Atlantic and invaded Maryland with its associated faunas cannot be satisfactorily determined at this time. Its present main interest and value is as a guide fossil that helps other fossils in proving the Rochester age of at least some part of the Upper Clinton as developed in Pennsylvania and Maryland.

In the Red Mountain Clinton of Alabama remains of Bryozoa are rather common and very similar in character to those found in the Wolcott limestone in New York. But none of the other kinds of fossils associated with them is a distinctly Atlantic type. Besides, the Alabama deposits of this age are separated from the southern extremity of the Middle Appalachian Clinton trough by more than the width of the State of Tennessee in which deposits of Clinton age are almost entirely absent. It appears, therefore, the Alabama Clinton faunas are entirely southern in origin.

Reverting to the Rochester fauna of New York it is to be observed that in the collections made at Lockport and Rochester this fauna contains about 20 species of Ostracoda, trilobites and graptolites that we regard as North Atlantic types and not as southern. This conclusion is based on two facts, (1) most of them are either specifically the same as, or have their closest allies among species found in the Appalachian Valley region north of Tennessee; (2) none of them has been found in rocks of Silurian age in the Ohio and Mississippi valleys whose faunas may be confidently viewed as having invaded the continent from the south. In addition to these 20 Atlantic species the typical Rochester fauna includes a few brachiopods, notably Clorinda, *Nucleospira pisiformis,* and *Stropheodonta profunda,* which while common in Atlantic faunas of this time are rare or not found at all in southern faunas before Upper Niagaran time. The only manner in which we can account for these facts is by assuming sufficient communication between the southern and eastern waters during the Rochester and Irondequoit stages of the Upper Clinton age to permit such intermingling of faunas. The connection between the two seas must have occurred across north central Pennsylvania.

As already indicated the Upper Clinton was a time of general though oscillating subsidence in the middle Appalachian and Allegheny Plateau regions. But the subsidence was never sufficient to permit unrestricted and general blending of faunas. Most of the transfusion was from the east westward and much of the latter concerned crustacea that seem better travelers and less susceptible to changes in environment than other classes of marine animals. Among them are *Paraechmina spinosa, P. abnormis, Dizygopleura symmetrica, Bythocypris niagarensis,* species of Octonaria, *Dalmanites limulurus* and *Homalonotus delphinocephalus,* all of which occur in the Upper Clinton of Maryland and Pennsylvania but not in the Ohio Valley. The nine dendroid and reticulate graptolites that have been described from the Rochester in western New York are wholly unrecorded in southern Silurian faunas except perhaps one or two cosmopolitan species of Dictyonema which are found also in the Cataract formation in Ontario and the Brassfield in Ohio. Graptolites of the same types do, however, occur in the Atlantic faunas of the east, though it must be confessed that their remains are not common in the Appalachian Clinton formations.

Besides the 20 or more species in the Rochester fauna of western New York which have been picked out as probably having been derived from the east this fauna includes five or six pelecypods that also suggest an eastern rather than a southern origin. However this question may finally be decided, it cannot be denied that most if not all of the Rochester pelecypods have very close and perhaps indistinguishable allies in the Clinton faunas of Pennsylvania. As yet, however, the Clinton pelecypods require closer investigation not only of their structural characters but also regarding both their geographic distribution and their vertical range before their testimony in questions of correlation may be properly appreciated and evaluated.

UPPER CLINTON FORMATIONS.—Continuing with the New York section, the first of the Upper Clinton formations is the Williamson shale as redefined by Chadwick. In the section at Rochester the true Williamson is represented by only the five or six feet of dark graptolite-bearing shale which lies immediately beneath the Irondequoit limestone. Going eastward from Rochester this shale formation increases to its supposed maximum of about 100 feet in the deep well at Lakeport. Beneath it in this well is a shaly limestone that all agree is the Wolcott limestone. To the east of Lakeport the Williamson thins so rapidly and changes so greatly in lithological character in the largely drift-covered 25 miles that intervene between this place and the outcrops at Clinton that some doubt exists as to its presence in the section at the latter place. If, as we think is highly probable, the Williamson shale is represented in the typical section of the Clinton, then it must be by that part which begins with the oolitic iron ore bed and extends above the ore to some undetermined line in the overlying 18 feet of interbedded soft shale and harder calcareous shale.

More than 40 species of fossils were collected by the senior author from the greenish soft shale that is removed with the ore in mining the oolitic bed at Clinton. From one to two feet of this shale lies between the two ore benches, and we were assured by the miner that no more than a foot or two of the shale that overlies the upper bench is ever removed in the mining operations. Though most of the fossils came from the roof of the mine it is certain that a part of the collection is from the shale parting. So far as observed there is no essential difference between the fossils found immediately above and beneath the upper of the two oolitic layers.

This and other collections of fossils made at Clinton are exceedingly important in determining the age relations of Maryland Upper Clinton zones to those in New York. Lists are given on following pages. Here we are concerned more particularly with the relation of the oolitic iron ore and the fossiliferous shale that is intimately associated with it at Clinton to the typical Williamson shale.

According to present conceptions the most characteristic fossil of the Williamson shale is *Monograptus clintonensis*. This graptolite occurs in the oolitic iron ore zone at Clinton. The Williamson also has the first of the Clinton occurrences of Plectambonites (probably *P. elegantulus*) and the same species occurs with the Monograptus at Clinton. A third characteristic fossil that is found in both is a supposedly new species of Ischadites. These three species—especially in view of the fact that none of the other fossils associated with them in either the typical Williamson or in the shales that are associated with the oolitic ore at Clinton tend to contradict their testimony—should suffice in establishing the essential contemporaneity of the two beds. Regarding the other fossils in both beds we may add that by far the greater number of them are decidedly much more closely allied to succeeding Irondequoit and Rochester species than to the older Middle and Lower Clinton species.

In the more limy zone which lies from 3 to 15 feet above the oolitic ore at Clinton is another fauna. A number of the species of the underlying bed pass into this zone, but the introduction of four or five other species gives it a distinct aspect that seems to be quite characteristic of the zone. Among the added forms are *Dalmanella elegantula, Bilobites biloba,* and *Nucleospira pisiformis,* three prolific members of the Irondequoit and Rochester faunas. But the most abundant and also the most striking of the new things is the coral *Palaeocyclus rotuloides,* and this, moreover, seems to be confined to this zone.

Clinton Section at Clinton, N. Y.

The general character and relations of the Clinton section at Clinton, New York, is given below followed by columnar sections showing the sequence of beds at Rochester, Wolcott, Lakeport, Clinton, and Cruger's Mill on Days Creek.

SECTION AT CLINTON, N. Y.

	Feet
Clinton group	
Unexposed beds of undetermined but evidently small thickness	?
Upper Clinton	
9. Calcareous sandstone, rather thin bedded, with thin shaly layers (Herkimer sandstone of Chadwick), about	50
8. Red flux iron ore bed, filled with broken remains of Rochester Bryozoa	3-6
7. Thin, irregularly bedded calcareous sandstones in upper half and thinner layers of arenaceous shale in lower half	7
4. Hard, streaky, ferruginous and clayey suboolitic limestone, full of large and small crinoid columnals and a few undetermined Bryozoa	2
(Beds 6 and 7 probably correspond to the Irondequoit limestone at Rochester and to the Keefer sandstone of Maryland and Pennsylvania.)	
5. Bluish or greenish shale with thin layers of sandy, often fossiliferous limestone mainly in the middle third; fossils: *Palaeocyclus rotuloides, Dalmanclla elegantula, Bilobites biloba, Nuclcospira pisiformis, Mastigobolbina punctata, Plethobolbina typicalis*, etc. At base a softer shale with large and partly different fauna, including Monograptus and other graptolites	18
4. Oolitic iron ore locally in two beds with a fossiliferous shale parting; and occasional quartz pebbles in base	2.5-3
(Beds 4 and 5 correspond to the Williamson shale of Wayne County, and to the Mastigobolbina typus zone in Pennsylvania, Maryland, Virginia, Kentucky, and Ohio.)	
Middle and possibly Lower Clinton	
3. Greenish shale and very thin sandstone layers, almost barren of fossils; exposed about	25
Unexposed but as indicated by log of deep well:	
2. Shale with beds of sandstone about	105
1. Oneida conglomerate	50
Ordovician	
Frankfort shale	
Shale, light colored and sandy	50
Dark shale	662
Trenton limestone in bottom of well.	

As indicated above in the section at Clinton beds 4 and 5 are correlated with the Williamson shale, and beds 6 and 7 with the Irondequoit. However, bed 8, the conglomeratic red flux ore bed, must be a younger formation. It consists mainly of cemented crinoid columnals and fragments of common Rochester shale Bryozoa. Although only a small part of the material collected from this bed has been subjected to study at least nine

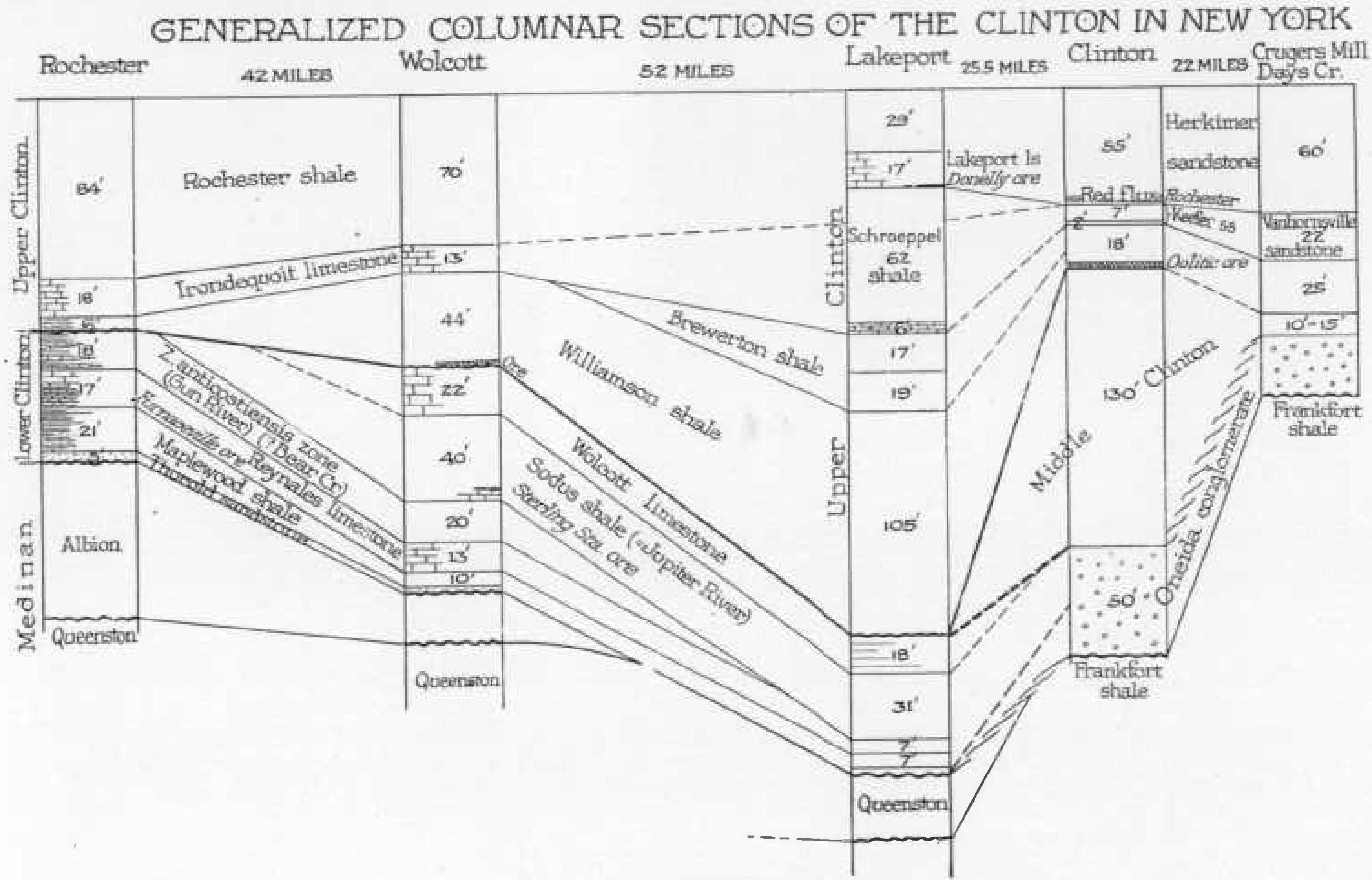

FIG. 26.—GENERALIZED COLUMNAR SECTIONS OF THE CLINTON IN NEW YORK.

Rochester species were recognized in it. These are: *Chilotrypa ostiolata, Hallopora elegantula, Batostomella granulifera, Eridotrypa solida, Lioclema asperum, Nicholsonella florida, Phænopora canadensis, Pachydictya crassa,* and *Clathropora frondosa.* Besides these there were specimens of two wider species of Phænopora, others of a species of Meekopora that may be the *M. bassleri,* and finally a few of a species of Rhinopora. Remains of other classes are rare and poorly preserved. Among them is a brachiopod like *Whitfieldella oblata,* fragments of trilobites probably belonging to *Calymene niagarensis* and *Dalmanites* cf. *limulurus.* Also two undetermined cup corals. Further search doubtless would reveal other species of like stratigraphic significance but in the absence of anything of opposing nature it has seemed unnecessary to seek additional proof of the Rochester age of the red flux ore bed.

In making this assignment of the red flux ore bed to the age of the Rochester shale it is to be understood that we contemplate merely a stage following the termination of Irondequoit limestone deposition in western New York. The red flux ore bed accordingly would represent some part of the lower half of the Rochester shale leaving the overlying sandstone in the Clinton section to represent higher parts of the Rochester.

Chadwick denied the presence of beds corresponding stratigraphically to the Rochester shale in the section at Clinton. The evidence cited by him in support of his view consists mainly of unproved and altogether improbable assertions regarding progressive loss by erosion of members from the top of the Clinton in going eastward from Rochester. We, on the contrary, see no valid reason, either paleontological or physical, for any such conclusion. Of course, the top surface of the Clinton was subjected to some erosion during the eastwardly increasing time marked by the hiatus between its top and the overlapping base of the succeeding Lockport and Cayugan formations. But as commonly happened in such cases the amount of rock removed was comparatively insignificant.[1]

In this connection it should be remembered that Chadwick failed to recognize the Williamson age of the oolitic iron ore bed at Clinton which

[1] A good illustration of the almost inappreciable effect of erosion during long periods of Paleozoic emergence is the case of the Fernvale limestone in Missouri which, as described by Ulrich in the Revision of the Paleozoic Systems, p. 305, maintains approximately the same thickness whether the next succeeding bed is of a later Richmond age or a Mississippian formation.

he correlated with the Verona iron ore that lies at the base of the Wolcott limestone or lower. Also that he recognizes the Lower Clinton Sodus and Maplewood shales, and, doubtless inadvertently, also the "Martville" shale, in the Middle Clinton south and east of Utica. These misapprehensions probably are largely responsible for the belief in great erosion loss from the top of the Clinton. Nor should we overlook the unconcealed fact that Chadwick depended for his faunal evidence from localities in Oneida and Herkimer counties mainly on citations in the old reports by Vanuxem and Hall.

Judging from our own investigations none of the Clinton fossils so far collected at localities in Oneida and Herkimer counties indicates Lower Clinton; and in the latter county they are all of Upper Clinton age. Obviously then, the eastward thinning of the Clinton is mainly by overlap and consequent loss of beds from the bottom instead of from the top.

Ostracod Zones of the Clinton

Study of the field relations of the Clinton Ostracoda described in this volume has brought out the fact that they occur in a number of more or less clearly distinguishable zones. Nine of these zones are recognized; and those species that are confined to one or another of the zones constitute by far the majority of the total number. Most of the remainder are common to two of the zones, while a few may even be found in three. The latter, however, are of the relatively simple forms among which close specific discrimination is difficult.

Each of the major divisions of the Clinton—commonly designated in this work as Lower Clinton, Middle Clinton, and Upper Clinton—comprises three zones, arranged and named as in the following table:

CLINTON OSTRACOD ZONES IN THE APPALACHIAN VALLEY REGION

9. Drepanellina clarki zone..........	Upper Clinton or Lakemont formation
8. Mastigobolbina typus zone.......	
7. Bonnemaia rudis zone...........	
6. Zygosella postica zone...........	Middle Clinton
5. Mastigobolbina lata zone..........	
4. Zygobolbina emaciata zone.......	
3. Zygobolba decora zone...........	Lower Clinton
2. Zygobolba anticostiensis zone....	
1. Zygobolba erecta zone...........	

Except the two uppermost zones, which are separated by the Keefer sandstone, it is not claimed that these zones are definitely limited above and below. Possibly such limits might be established if one could find and study very carefully the several beds in perfectly exposed sections. But such favorable exposures of Clinton deposits are seldom found in the Appalachian Valley, and those that have been observed rarely extend through more than two or three of the zones. Nearly always some much needed part is covered. Besides the successive beds of shale and sandstone are so much alike in lithologic character and so many prove practically barren of organic remains that the criteria usually relied on in separating members of formations are only very imperfectly serviceable in this case.

For the present, then, most of these fossil zones serve mainly in giving an approximate indication of particular horizons in an otherwise exceedingly uncertain sequence of deposits. Each zone is recognized and distinguished from the others by one to ten or more species of Ostracoda whose vertical range has been established by field experience, careful collecting and exhaustive study and comparison of everything contained in each collection. Some species were thus shown to range through hundreds of feet of beds. Many others, on the contrary, seem to be confined to much narrower vertical limits. Fortunately, most of them occur in veritable swarms, and it is only very seldom that a species occurs unaccompanied by others. Though the usual presence of a number of more or less closely related forms in each of the fossiliferous layers adds to the difficulty of identifying the specimens, the combinations of two or more closely drawn characteristic species makes the extra trouble worth while by adding greatly to the certainty of their age determination.

As might be expected, certain of these zones are not only more definitely determinable but also more easily than others. Some also, and this applies particularly to the first (*Zygobolba erecta*) and sixth (*Zygosella postica*) zones, are known to occur at only a few places. The seventh, Bonnemaia rudis zone, also has not been recognized in many of the Clinton sections. This is unfortunate because the B. rudis zone is perhaps the most prolific of the Clinton ostracod zones and very easily distinguished from the underlying zones. At the four places where this zone has been recognized—one in central Pennsylvania, one in Maryland, one in southwestern Virginia, and one in northeastern Tennessee—occasional thin sandstone layers in it are simply crowded with large specimens of *Bonnemaia rudis* and other species of this genus that have so far been found only in this zone.

Considering the geographic distribution of the Ostracoda of each of the three major divisions of the Clinton we quickly learn that in each case it is the middle zone that is the most widely and generally distributed. In Lower Clinton exposures the second or Zygobolba anticostiensis fauna is recognized oftener than are either the underlying Z. erecta zone or the overlying Z. decora zone. In the Middle Clinton the Mastigobolbina lata fauna is much more persistent than either the Zygobolbina emaciata or the Zygosella postica faunas. And so also in the Upper Clinton it is the Mastigobolbina typus zone that is always present, whereas either or both of the two other zones of this division may be absent or at least unrecognizable over wide areas. These facts suggest shifting of seas and alternating retreat and advance of shore lines.

The general absence of the Z. erecta fauna except in central Pennsylvania (Blair, Mifflin, Huntingdon, Juniata, and Perry counties), considered with the two facts (1) that where it is present the Clinton section as a whole is thicker than elsewhere and (2) where it has not been recognized the second or Z. anticostiensis fauna lies nearer the base of the Clinton than it does in sections showing both zones, suggests the inference that the Clinton sea first invaded central Pennsylvania and in the second stage spread from there northward to western New York and southward to southwestern Virginia. At the close of the second stage, however, the Appalachian sea retreated from the south so that the third or Z. decora fauna is confined to the area between northern Virginia and central New York. Similarly, the Zygobolbina emaciata fauna has been recognized in typical development only in south central Pennsylvania, whereas the succeeding Mastigobolbina lata fauna is well developed in Oneida County, New York, and generally present in the Clinton sections in Pennsylvania, Maryland, and Virginia. But on this occasion the sea apparently retreated from the north so that the succeeding Zygosella postica fauna is found only to the south of Pennsylvania.

A generalized statement of geographic changes during the Upper Clinton has already been given in discussing the New York Clinton section. Here it will suffice to say that the patchy distribution of the Bonnemaia rudis zone from central Pennsylvania to northern Tennessee indicates preceding slight warping of the Appalachian region, with increasing subsidence to the southwest. The submergence of the succeeding Mastigobolbina typus stage involved a much wider area extending to southern Ohio on the west and to New York on the north.

Evidently tilting of the surface of eastern United States occurred alternately in northeast and southwest directions, the area of submergence increasing toward the north when the tilt took that direction and to the south and west when the direction of the tilt was reversed. The process was further complicated by similarly alternating differential movements in east-west directions, which caused considerable overlap by deposits and faunas of southern origin over the western edges of deposits that had been laid down by Atlantic waters; and vice versa. In consequence of these various differential movements and warpings of the surface of the continent the geographic pattern was ever changing. The more important of these are shown in paleogeographic maps in another chapter.

CLINTON SECTIONS IN PENNSYLVANIA AND MARYLAND.—In view of the preceding observations it is not to be expected that all of the nine Clinton ostracod zones should be generally found and clearly recognized in all or even in many widely separated exposures of the group. In fact they are not generally present or at least not so developed that one may always be certain as to what is or is not present. Still, some sections are known in Pennsylvania and Maryland in which most if not all of the zones have been recognized. To insure the removal of all doubt in the mind of the reader that these zones are not based on merely local variations of the Clinton fauna but are actually superposed one over the other, a few of such sections will be given. The most complete of these sections occurs in Juniata County, Pennsylvania, on the northwest slope of Tuscarora Mountain between Honey Grove (sometimes called Bealetown) and the edge of Perry County. Another, in the same state, is 1 mile north of Marklesburg in Huntington County; the third, also in Pennsylvania, is at Hollidaysburg; the fourth at Cumberland, Md.

SECTION NEAR HONEY GROVE, PA.

The following very complete section was measured by Charles Butts and E. O. Ulrich, and the fossils were determined by the latter:

SECTION OF THE CLINTON GROUP ON FLANKS OF TUSCARORA MOUNTAIN, SOUTHEAST OF HONEY GROVE, JUNIATA COUNTY, PENNSYLVANIA

Cayugan: McKenzie formation

Niagaran

Upper Clinton

Drepanellina clarki zone — Feet

Soft pale yellow and greenish calcareous shale with the characteristic ostracods and shells of this zone.......... 50

Keefer sandstone member

Hard, thick-bedded quartzose sandstone in lower part and more flaggy fossiliferous sandstone in upper third, about. 20

Fossils: 2 sizes of "Monocraterion"-like worm burrows, *Dalmanella* cf. *elegantula*, *Rhipidomella* cf. *hybrida*, *Rafinesquina* sp., *Orthotetes* sp., *Spirifer crispus*, *Camarotœchia* cf. *plicatella*, *Modiolopsis* sp., *Ischyrodonta* ? sp., *Ctenodonta* sp., *Tentaculites* sp., *Leperditia* sp., *Dizygopleura* sp., *Calymene* cf. *blumenbachi*, *Homalonotus* cf. *delphinocephalus*.

Mastigobolbina typus zone

Greenish and purplish shale with plates of sandstone, the latter often fossiliferous, about........................ 100

Fossils: *Dalmanella* cf. *elegantula*, *Chonetes cornutus*, *Anoplotheca obsoleta* Ulrich (outline rounded and plications nearly obsolete—characteristic of this and underlying zones), *Mastigobolbina typus*, *M. triplicata*, *M. punctata*, *Plethobolbina typicalis*, *Bonnemaia celsa*, *B. crassa*, *B. longa*, *B. perlonga*, *B. obliqua*, *Zygosella vallata*, *Z. nodifera alta*, *Liocalymene clintoni*.

Bonnemaia rudis zone

Interbedded sandstone and shale, certain layers filled with the fauna of this zone, about........................... 100

Fossils: *Anoplotheca obsoleta*, *Bonnemaia rudis*, *B. fissa*, *B. longa*, *Mastigobolbina bifida*, *Zygosella vallata* var., *Calymene* "*blumenbachi*," *Liocalymene clintoni* ?, *Tentaculites* sp.

Middle Clinton

Faunal zones not indicated by fossils; upper part perhaps Upper Clinton

Shale and sandstone, the former dark green but weathering to purple tints, the latter more or less ferruginous, mainly fine grained and weathering rusty. No fossils observed. If present should include the Zygosella postica zone; about. 200

	Feet
Highest observed appearance of the Mastigobolbina lata fauna	
Shale and sandstone like the overlying 200 feet, but several beds contain fossils of the M. lata fauna; about..........	50
Fossils: *Dalmanella* aff. *elegantula*, *Chonetes* sp. (same in Zygobolba decora zone), *Mastigobolbina lata*, *M. vanuxemi*, *Zygobolbina emaciata* ?, *Z. conradi*, *Plethobolbina* sp., *Calymene* "*blumenbachi*," *Liocalymene* cf. *clintoni* and crinoid columnals.	
Covered except for occasional thin ledges of blocky ferruginous sandstone, the covered spaces probably mostly shale. No fossils observed; about..............................	100
Poorly exposed band with thin fossiliferous sandstone; about....	20
Fossils: *Zygobolba arcta*, *Z. bimuralis*, *Zygobolbina emaciata* ?, *Mastigobolbina lata nana*, *M. vanuxemi*, *Calymene* "*blumenbachi*," *Liocalymene* cf. *clintoni*, *Bucaniella trilobata*, and two undeterminable trepostomatous Bryozoa. Evidently an early Middle Clinton fauna though not a typical expression of the Z. emaciata zone.	
Covered	40
Lower Clinton	
Zygobolba decora and ? Z. anticostiensis zones	
Showing mainly as surface debris with occasional bands of thin sandstone in place. Many of the slabs of sandstone are fossiliferous, especially in the upper part; about......	200
Fossils: *Zygobolba decora*, *Z. elongata*, *Z.* cf. *erecta*, *Z. carinifera*, *Z. robusta*, *Z. intermedia*, *Zygobolbina carinata*, crinoid columnals, *Chonetes* sp., *Liocalymene* cf. *clintoni*.	
The lower two-thirds of this interval was only very hurriedly searched for fossils. There being ample space for the Zygobolba anticostiensis zone it seems probable that more careful investigation would reveal the fauna of this zone also.	
? Zygobolba erecta zone	
Vermilion and brownish red sandstone in thin layers, some of them fossiliferous, about......................	20
Fossils: *Mastigobolbina* cf. *incipiens*, *M. producta*, *Zygobolba anticostiensis* ?, *Chonetes* sp., *Anoplotheca hemispherica*, *Liocalymene* n. sp.	
Covered space to top of Tuscarora sandstone; about...........	40
Total thickness of Clinton about..................	940

It is to be regretted that only an hour or two was devoted to the collection of fossils from the lower 650 feet of this great Clinton section. With more time, doubtless, other and probably more characteristic expressions of the fossil zones would have been found. As it is we have one fairly characteristic Middle Clinton fauna, the M. lata zone being clearly indicated by the listed species. But the next underlying fossiliferous zone which lies 100 feet beneath the M. lata bed lacks some things, mainly other than Ostracoda, that one would expect in a typically developed Zygobolbina emaciata fauna. It may be either a little younger or older. The Lower Clinton fauna that was collected some 40 to 80 feet lower in the section contains a number of the most characteristic species of the Z. decora zone, but with these are specimens like *Zygobolba elongata, Z. erecta,* and *Z. carinifera* which have been referred to the Z. erecta zone. On the other hand, there is also *Zygobolbina carinata* which is a member of the Frankstown ore bed. However, the exact position of the last is not definitely known, though the probabilities strongly favor its being an upper subzone of the Z. decora zone and a possible contemporary of the Wolcott limestone and Wolcott Furnace ore bed of the New York section.

As stated above there is ample room in this section between the layers containing this possibly mixed facies of the Z. decora fauna and the next lower observed fossiliferous bed which lies about 150 feet beneath it for the apparently missing or at least undiscovered Z. anticostiensis fauna. In other words, there are beds here that may well correspond to that zone even if the fauna itself should prove to be absent here.

Regarding the lowest of the Clinton fossiliferous beds in the Honey Grove section even more doubt prevails than in the overlying cases. Only a single small hand sample of this was taken by Mr. Butts, who alone investigated the basal part of this section. The six species above listed were found in the laboratory when this rock sample was broken up. None of them is strictly characteristic of the Z. erecta fauna as typically developed in a similarly bright red sandstone and in the ore bed associated with it in the basal part of the Clinton section near Marklesburg, Pa. We are certain only that it is a Lower Clinton fauna; and it is referred provisionally to the Z. erecta zone for no other reason than that it occurs near the base of an uncommonly thick sequence of Clinton deposits.

No better place than this is likely to arise in this discussion of the Clinton faunal zones for the candid admission that the Lower Clinton in the Appalachian region is not readily divisible into three definitely recognizable zones. While there is practically no uncertainty and no difficulty worth mentioning in distinguishing the Lower Clinton faunas from those of Middle Clinton age, the case as yet is very different when one is called upon to decide the exact position of isolated collections of Lower Clinton faunas. However, such difficulties are to be expected, especially in the early stages of inquiries seeking to establish the stratigraphic sequence by modifications in the characters of species and in the combinations of forms or faunal associations. Evidently the changes in the specific characters came about slowly and gradually, and when we are dealing with the more or less frequently repeated invasions of the same fauna it is impossible to decide from the fauna itself whether the apparently incongruous elements in many of our fossil faunas are to be explained as forerunners or holdovers. It is only after thorough collecting in many places that we may finally learn to harmonize and evaluate the fossil evidence on which stratigraphic correlations must primarily rest. We have not reached this stage in the investigation of the Lower Clinton faunas in the Appalachian region. Here the depositional record is more complete than in most other places, and the transitional phases of the Atlantic Clinton fauna—more of which happen to be preserved than elsewhere—tend correspondingly to efface the sharper delimitation of the faunal zones that prevail in places like New York where the gaps in the section are greater and the total depositional record of the epoch is less complete.

In New York, the Island of Anticosti, and also at Cumberland, Md., the absolute distinctness of the Zygobolba anticostiensis and Z. decora faunal zones is undeniable. In these places the characteristic Ostracoda of each are confined to a few, or at least not exceeding 50 feet of beds; and within these limits the respective faunas are reasonably pure, if we may use this expression. However, in these thicker Pennsylvania sections which, moreover, probably lie nearer the Atlantic inlet and the orginating source of the fauna, the exact equivalent of what we are calling the " pure " expressions of these faunas may yet await discovery. Besides, here the chances of finding modified associations of intermediate as well as both preceding and succeeding stages of development are greater.

TUSSEY MOUNTAIN SECTION IN PENNSYLVANIA

Regarding the actual existence and perhaps independence of the Clinton zones just mentioned reasonable doubt is warranted at present only in the case of the lowest which is provisionally distinguished under the term Zygobolba erecta zone. So far as known it is typically developed only in the Tussey Mountain anticline. Here, as indicated in the following section, it lies 45 to 50 feet above the Tuscarora sandstone.

SECTION OF THE CLINTON GROUP ON THE SOUTHWEST SLOPE OF TUSSEY MOUNTAIN AND MAINLY AS EXPOSED IN A MINE TUNNEL 1 MILE NORTH OF MARKLESBURG, PA.[1]

	Feet
Cayugan series or group	
McKenzie formation—limestone and shale	
Niagaran	
Clinton group	
Upper Clinton or Lakemont formation	
Shale and thin layers of limestone, the Drepanellina clarki zone	60 ±
Sandstone, coarse, thickbedded, calcareous, ferruginous, fossiliferous, the Keefer sandstone member	10
Iron ore, fossiliferous	2
Shale, calcareous, representing the Mastigobolbina typus zone present but not separated from underlying shale, say about	40
Middle and Lower Clinton	
Shale usually soft and greenish, with thin fine-grained green or yellow layers of sandstone	575
Sandstone, hard, fine-grained, grayish to greenish, medium thick-bedded	40
Sandstone, ferruginous, blocky, yields red sandstone debris.	1-2
Fossils: The typical Zygobolba erecta fauna, comprising *Anoplotheca hemispherica, Tentaculites minutus, Eupri-mitia buttsi, Zygobolba carinifera, Z. elongata, Z. erecta, Z. limbata, Z. parifinita, Z.* cf. *arcta, Z. reversa, Z. pul-chella, Zygobolbina* cf. *emaciata.*	
Iron ore, oolitic, fine-grained, occasionally with inclusions of fossiliferous shale locally developed	4

[1] This section was measured by Mr. Charles Butts and subsequently verified as to its lower and upper parts by E. O. Ulrich.

	Feet.
Fossils: *Bythotrephis gracilis*, Arthophycus and other trails, *Anoplotheca hemispherica*, and numerous Ostracoda mainly of the genus Zygobolba but specimens too much weathered to be determined specifically.	
Shale, bluish	3
Sandstone, argillaceous, hard, fine-grained greenish	2
Shale	2
Sandstone, hard 3-inch flags	1.4
Shale, may have some thin sandstone layers	30
Sandstone, greenish and bluish gray, quartzose hard, fine grained	5
Shaly beds with thin firmer sandy layers	0-10
Total thickness about	793

Medinan

Tuscarora sandstone

In this Tussey Mountain section only the lower 60 feet of the Clinton was carefully searched for fossils. The Middle Clinton doubtless is represented in the 575 feet of shaly beds but was not differentiated from the Lower Clinton. However, the Keefer sandstone and the Drepanellina zone at the top of the section were satisfactorily identified.

CLINTON SECTION IN VICINITY OF HOLLIDAYSBURG, PA.

The zones of the Upper Clinton are very well displayed in highway and railroad cuttings in the vicinity of Hollidaysburg, Pa., especially at Lakemont Park, along the highway about midway between Hollidaysburg and Altoona. Large collections of fossils have been made at these places. Composite lists of these follow the description of the section.

SECTION OF THE UPPER CLINTON OR LAKEMONT FORMATION IN THE VICINITY OF HOLLIDAYSBURG, PA.[1]

	Feet
Cayugan series	
McKenzie formation, about	275
At the base one or two thick ledges of irregularly laminated argillaceous limestone, weathering into boulder-like masses, indicating reefy deposition; contains an abundant fauna comprising corals, Spirorbis, ostracoda, and brachiopods, all different from preceding faunules. As is to be expected the bed varies in thickness, appearance and in abundance of organic remains	

[1] Compiled from sections measured by Charles Butts, Edwin Kirk, and E. O. Ulrich.

	Feet
from place to place. In the roadside cut at Lakemont, about midway between Altoona and Hollidaysburg, the bed is 10 to 12 feet thick, characteristically developed and its relations to overlying and underlying beds well displayed. It is regarded as the initial deposit of the McKenzie formation.	
Niagaran series	
Clinton group	
Lakemont formation or limestone (Upper Clinton)[1]	
Drepanellina clarki zone	
Shale and limestone interbedded, the limestones subcrystalline, fossiliferous, in layers varying from one to six inches in thickness and aggregating nearly a third of the total. At the base one foot of limestone overlain by three feet consisting almost entirely of shale. The fauna is made up mainly of minute ostracoda, among which species of Paræchmina are prominent, and brachiopoda	18.0
Shale with fewer and thinner lenses and layers of sparingly fossiliferous limestone	13.0
Prominent, highly fossiliferous layer of limestone, 5 to 7 inches thick. The fauna comprises the usual brachiopoda and ostracoda of this zone. The most striking, largest and characteristic of the latter is *Drepanellina clarki*. Typical *Dalmanites limulurus* also is rather abundant	0.5
Brown and greenish shale, in part slightly sandy, with one to three thin (1 to 3 inches) layers of fossiliferous limestone in upper third to half and locally one in the lower half. Fossils indicate same fauna as in thicker limestone layer next above	33.0
Purple oolitic iron ore bed, often shaly in upper half, the whole varying from 12 to 8 inches	1.5
Total thickness of Drepanellina zone	66.0
Horizon of Keefer sandstone	
Conspicuous, thick-bedded zone of more or less sandy and ferruginous argillaceous limestone weathering ochreously brown and yellow, 8 feet to	12.0
	12.0

[1] The term Lakemont limestone or formation is proposed for the Upper Clinton as developed in central Pennsylvania. The type section is at Lakemont Park along the highway between Hollidaysburg and Altoona, Pa. The advantage of using this new name for the Upper Clinton in Maryland seems assured, but in southwestern Virginia where the corresponding beds consist entirely of sandstone and sandy shale some other designation probably is desirable. The propriety of its use for New York deposits of similar age also is questionable.

	Feet.
Mastigobolbina typus zone	
Mainly shale with more or less ferruginous thin layers of limestone in the upper half and at base, and one, two or three thin layers of fossiliferous oolitic iron ore in lower half, 6 feet to	9.0
Greenish calcareous shale including two or more 1- to 3-inch layers of fossiliferous limestone	8.5
Shale, the upper half or more usually of chocolate color, with a 3- to 4-inch layer of fossiliferous limestone next beneath and usually three or four 1- to 9-inch layers of similar limestone in the lower third or fourth, 7 feet to	8.5
Greenish, often slightly sandy shale, 4.5 feet to	6.0
Limestone, 0 to 9 inches, with a large fauna including nearly all of the common fossils of the zone besides *Paleocyclus rotuloides* which seems to be confined to this bed	0.7
Chocolate shale makes up most of the upper half and grayish or greenish shale the lower half. Between these two parts is a foot and one-half of greenish shale with intercalated thin seams of fossiliferous limestone. All of these contain *Mastigobolbina typus*, *Plethobolbina typicalis* and other ostracoda as well as brachiopoda that are characteristic of this zone	12.0
Total thickness of the M. typus zone	44.7
Middle and Lower Clinton shales and sandstones to top of Tuscarora sandstone, about	450

Beneath the M. typus zone the outcrop at Lakemont Park shows about 100 feet of mainly dark shale, with occasional bands weathering to purplish tints. This shale may correspond to the Williamson shale of New York, but the correlation is doubtful. Beneath it comes about 50 feet of more greenish and slightly arenaceous shale, suggesting some Middle Clinton zone, but in the absence of fossil evidence this possible correlation also is in doubt. The exposures of the underlying beds of the Clinton in this vicinity are always unsatisfactory, but the width of the areas involved and the dip of the exposed harder ledges makes it reasonably certain that the aggregate thickness of these lower beds of the Clinton is not less than 400 feet. The Frankstown ore bed, which closely underlies some very fossiliferous layers, occurs near the middle of these 400 feet. The fossils associated with it indicate a position well up in the Lower Clinton. Loose slabs of laminated sandstone, filled with fossils, indicating the Zygobolba decora zone, occur in such a position as to suggest the presence of this zone about 50 feet beneath the horizon of the Frankstown ore. Near the base of the Clinton is another fossiliferous iron ore horizon that may correspond to the Zygobolba erecta zone which lies near the bottom of the Clinton in the Tussey Mountain section near Marklesburg given on a preceding page. The total thickness of the Clinton in the vicinity of Hollidaysburg, Pa., is approximately 660 feet.

So far as determined the fossils found in these Clinton zones in the vicinity of Hollidaysburg, Pa., may be listed as follows, beginning at the top and proceeding downward through the section to the top of the underlying Tuscarora quartzite:

COMPOSITE FAUNA OF THE DREPANELLINA CLARKI ZONE OF THE LAKEMONT FORMATION IN THE VICINITY OF HOLLIDAYSBURG, PA.

Zaphrentis sp. (cf. Polydilasma turbinatum Hall)
Duncanella ? sp.
Pholidops squamiformis
Leptæna rhomboidalis
Brachioprion
Stropheodonta aff. profunda
S. cf. striata
Schuchertella subplana
Dalmanella elegantula
Rhipidomella hybrida
R. cf. circulus and hybrida
Anoplotheca cf. obsoleta (in extreme base)
Atrypa reticularis (Rochester shale varieties)
Nucleospira pisum
Whitfieldella oblata
W. cf. nitida
Eospirifer sp. (with 2 or 3 broad plications on each side of fold)
Delthyris bicostatus
Camarotœchia neglecta
C. aff. neglecta
C. aff. acinus
C. aff. whitei
Camarotœchia sp. (sinus nearly obsolete)
Rhynchonella ? cf. robusta and plicatella (Hall)
Chonetes aff. cornutus
Diaphorostoma niagarensis
Orthoceras sp. (small and tapering rapidly)
Cornulites sp. cancellatus
Paræchmina spinosa
Paræchmina postica
Drepanellina clarki
D. modesta
Beyrichia veronica
Klœdenia cacaponensis
Haploprimitea sp.
Klœdenella sp.
Dizygopleura lacunosa
D. symmetrica
Bythocypris sp.
Leperditia aff. alta
Calymene niagarensis
Homalonotus delphinocephalus
Dalmanites limulurus
? Onchus deweyi

FAUNA OF THE MASTIGOBOLBINA TYPUS ZONE IN THE VICINITY OF HOLLIDAYSBURG, PA.

Paleocyclus rotuloides
Favosites sp. (small, hemispheric)
Crinoid columnals (¼ to ½ inch diameter)
Dalmanella elegantula
D. cf. elegantula (small variety)
Leptæna rhomboidalis (Clinton variety)
Stropheodonta corrugata
S. aff. profunda
Schuchertella subplana
Plectambonites transversalis
Chonetes cornutus
C. sp. undet.
Spirifer bicostatus
S. aff. eudora
S. cf. niagarensis
S. radiatus
Atrypa reticularis
A. cf. nodostriata
Anoplotheca obsoleta Ulrich n. sp.
Atrypina disparilis
Whitfieldella cf. crassirostrum
Nucleospira pisiformis
Rhynchotreta ? robusta
Camarotœchia aff. acinus
C. aff. indianensis
C. aff. neglecta
C. aff. whitei
Cyrtoceras cf. cancellatum
Cornulites flexuosus
Eridoconcha rotunda
Haploprimitia aff. humilis
Apatobolbina granifera
Paræchmina crassa
P. punctata
Klœdenia cacaponensis?
Zygosella vallata
Plethobolbina typicalis
P. ornata
Bonnemaia crassa
B. celsa
Mastigobolbina arctilimbata
M. arguta
M. glabra
M. intermedia
M. punctata
M. trilobata
M. triplicata
M. typus
Beyrichia kirki
B. lakemontensis
Dizygopleura symmetrica
D. loculata
Bythocypris sp.
Xestoleberis sp.
Pterinea emacerata
Hormotoma cf. subulata
Diaphorostoma niagarensis
Tentaculites cf. minutus
Calymene aff. niagarensis
Liocalymene clintoni
Dalmanites clintonensis Ulrich n. sp.
Homalonotus cf. delphinocephalus

Middle Clinton faunas probably present but not collected from the vicinity of Hollidaysburg, Pa.

LOWER CLINTON FAUNAS

FAUNA COLLECTED FROM SHALES, SANDSTONES, AND THIN LAYERS OF IRON ORE 6 TO 10 FEET ABOVE THE MAIN FRANKSTOWN ORE BED NORTH OF HOLLIDAYSBURG, PA.

Crinoid columnals and plates
Helopora, 2 species, perhaps the same as forms occurring in the Jupiter River formation on the Island of Anticosti
Phænopora sp.
Ramose and unilamellar species of Bryozoa, specifically undeterminable
Dalmanella aff. elegantula
Apatobolbina appressa
Chilobolbina cf. billingsi
Mastigobolbina retifera
Mastigobolbina incipiens
M. producta
Klœdenia obscura
Zygobolba buttsi
Z. rustica
Z. pulchella
Z. obsoleta
Zygobolbina emaciata?
Z. carinata
Z. conradi latimarginata?
Z. panda
Calymene aff. blumenbachi

The presence of three species of Mastigobolbina and four of Zygobolbina in this fauna suggests at least a late Lower Clinton time if not rather an early Middle Clinton stage. Provisionally it seems best to view the Frankstown ore horizon as a but locally developed and distinguishable subdivision of the Zygobolba decora zone that is marked particularly by *Mastigobolbina retifera* and *Zygobolbina carinata.* Compared with the beds of the New York Clinton it should fall in somewhere between the top of the Sodus shale and the base of the Middle Clinton. It may then correspond, at least in apparent position, to either the typical Wolcott limestone or the Wolcott Furnace ore. However, this does not mean that we regard the two as contemporaneous. The faunas of the respective beds are totally different in character and origin, that of the Wolcott limestone and iron ore being of southern origin whereas the Frankstown ore fauna is no less clearly of the Atlantic facies of the time. In view of the fact that the two faunas are not found in the same localities, either as separate entities or in commingling form, we must conclude either that they represent slightly different ages or, if strictly of the same age, that commingling of the southern and eastern faunas was prohibited by some land barrier. Though provisionally inclining to the former alternative we must admit the almost equal plausibility of the latter conception.

FOSSILS OF THE ZYGOBOLBA DECORA ZONE, FOUND IN THIN-BEDDED SANDSTONE ABOUT 50 FEET BENEATH THE FRANKSTOWN IRON ORE HORIZON NEAR HOLLIDAYSBURG, PA.

Unilamellar bryozoan (? Ceramopora)
Anoplotheca hemispherica
Anoplotheca sp. (small rounded form)
Rafinesquina cf. corrugata
Tentaculites minutus
Zygobolba decora and other species of the family

BASAL CLINTON FOSSILS (FROM SAME PLACE AS THE PRECEDING)

Anoplotheca hemispherica
Euprimitia buttsi
Zygobolba erecta
Zygobolba carinifera
Pterinea ? sp. nov. (closely allied to a Medina species)

The ostracods and brachiopod of this small list occur in a gray, very finely sandy shale that directly follows a coarser and rather heavy bedded highly ferruginous sandstone. The latter lies but a few feet above the Tuscarora and is known as the red keel or hard fossil ore. Its fossils apparently consist almost entirely of pelecypods, and of these only the listed Pterinea is abundant and in condition to be determined generically. The three ostracods in the shale above the red sandstone are all believed to be characteristic of the Zygobolba erecta zone as developed in the Tussey Mountain section between Marklesburg and Cherrytown about 12 miles to the east of Hollidaysburg.

CLINTON SECTION AT CUMBERLAND, MD.

The Clinton rocks are not so continuously exposed as desirable in the vicinity of Cumberland but the following is probably a reasonable approximation to the sequence as known.

SECTION AND FOSSILS OF THE CLINTON GROUP IN THE GORGE OF WILLS CREEK AT CUMBERLAND, MD.

	Feet
Cayugan series	
McKenzie formation, about	250
Niagaran series	
Clinton group	
Upper Clinton (Lakemont formation)	
Drepanellina clarki zone	
Mainly dark shale with frequent layers of bluish crystalline fossiliferous limestone	35

Feet

Fossils: *Dalmanites limulurus* characteristic of the lower two-thirds and *Nucleospira pisiformis* abundant in upper third. Ostracoda occur in most of the limestones but are particularly abundant and represented by the following species in a layer about 25 feet above the Keefer sandstone: *Drepanellina clarki, D. modesta, Beyrichia veronica, Laccoprimitia resseri, Paraechmina abnormis, P. cumberlandica, P. postica, P. spinosa, Dizygopleura asymmetrica, D. proutyi, D. symmetrica, Aparchites alleghenicnsis.* About 50 other kinds of fossils have been found in this zone and are described in this volume by Professors Prouty and Swartz.

Keefer sandstone member

Sandstone, gray, quartzitic, in part ferruginous, especially at top 10

Mastigobolbina typus zone

Olive or gray shale with thin limestone at top and a ledge of ferruginous and highly fossiliferous sandstone 30 to 32 feet beneath top 70

Fossils: *Dalmanella* sp., *Rhynchonella neglecta, R.* aff. *bidentata, Anoplotheca obsoleta, Whitfieldella* sp., *Delthyris* cf. *crispus, Mastigobolbina typus, M. triplicata, Plethobolbina typicalis, P. cornigera, Bonnemaia celsa, P. crassa, Dizygopleura symmetrica, Liocalymene clintoni.*

Bonnemaia rudis zone

Brownish or reddish ferruginous shale with the following Ostracoda: *Bonnemaia obliqua, B. pulchella, B. longa, Mastigobolbina virginica* 25

Middle Clinton

Zygosella postica-Mastigobolbina lata zones

Shales, greenish and olive, mostly concealed, apparently consisting mainly of soft beds with occasional thin sandstone, about 265

Fossils: Three fossiliferous zones, all indicated by loose sandstone slabs, were observed in the upper 235 feet of this series of beds. The first occurs about 170 feet beneath the Keefer sandstone. This contains *Homaeospira* aff. *apriniformis, Chonetes novascoticus, Calymene cresapensis* ?, *Zygosella postica, Z. brevis, Z. gracilis,* and *Mastigobolbina modesta,* the Ostracoda clearly indicating the Zygosella postica zone. The second lies about 100 feet lower in the section (275 feet above the Tuscarora). Here only ostracods were found indicating an upper layer of the Mastigobolbina lata zone: *Zygobolbina conradi, Z.*

Feet

conradi-latimarginata, *Zygosella brevis*, *Zygobolba bimuralis*, and *Z. arcta*. The third lies approximately 50 feet beneath the second (35 feet above the Cresaptown iron sandstone). The steel gray sandstone slabs here contained a typical expression of the Mastigobolbina lata fauna. Associated with the mentioned guide fossil are *Mastigobolbina vanuxemi*, *M. clarki*, *Zygobolbina conradi*, *Z. conradi-latimarginata*, *Chilobolbina billingsi*, *C. punctata-brevis*, *Tentaculites minutus*, and *Anoplotheca* aff. *hemispherica*. Beneath these three fossiliferous beds collections were made recently by the senior author and Mr. R. D. Mesler from green shale 9-14 feet above the Cresaptown ore and from a thin layer of sandstone 2 or 3 feet above the ore. In both of these layers Ostracoda are exceedingly abundant and well preserved, the commonest being *Zygobolba bimuralis*. The lower of the two is referred to in the descriptive part of the work as 173 feet above the Tuscarora sandstone. The new collections contain undescribed species.

Cresaptown iron sandstone, Zygobolbina emaciata zone

Sandstone, coarse grained, in part conglomeratic, highly ferruginous, including a few seams that contain determinable Ostracoda and other fossils. Among them we recognize *Anoplotheca* cf. *hemispherica*, *Tentaculites* cf. *minutus*, *Zygobolbina emaciata*, *Zygobolbina* cf. *conradi* and *Mastigobolbina* aff. *lata*. The Z. emaciata being abundant and of the typical form this bed may be regarded as corresponding to this zone............ 3-10

Lower Clinton

Zygobolba decora and Z. anticostiensis zones

Shale with occasional thin layers of sandstone, the latter often containing fossils, mainly Ostracoda, and becoming thicker and more abundant in the lower 50 feet... 170

Fossils: Four fossiliferous horizons were observed in these 170 feet of beds: the first in a thin sandstone about 20 feet beneath the Cresaptown iron sandstone, the second in a similar layer of sandstone 5 feet lower, the third in a half-inch layer 72 feet beneath the iron sandstone (98 feet above the Tuscarora sandstone), the fourth in shaly sandstone about 40 feet lower (55 to 60 feet above the Tuscarora). The first two of these fossiliferous layers contain *Zygobolba decora* and other species of its zone with Anoplotheca, Tentaculites and other fossils; the third contains numerous Ostracoda and shells of

Feet

Anoplotheca, the former suggesting the Z. anticostiensis zone perhaps as much as the Z. decora zone. Closer study of recently procured material from this third layer needs to be made before a decision as to its relations to the mentioned zones is warranted. However, the fourth fossiliferous bed, which lies between 55 and 63 feet above the Tuscarora sandstone, is less doubtful. It contains many ostracods and a few brachiopods like *Anoplotheca hemispherica* and *Chonetes novascoticus*. Also one or two undetermined pelecypods. The ostracods clearly indicate the Zygobolba anticostiensis zone. The following species have been identified: *Aparchites variolatus*, *Paræchmina* n. sp., aff. *spinosa*, *Beyrichia emaciata*, *Plethobolbina cribraria*, *Zygobolba anticostiensis*, *Z. curta*, *Z. excavata*, *Z. oblonga*, *Z. rectangula*, *Z. twenhofeli*, and *Zygobolbina* cf. *emaciata*.

Total thickness of Clinton group about........ 585

Among the important facts brought out by the section at Cumberland is (1) the absence of the lowest of the Clinton zones, namely the Zygobolba erecta zone, observed in the preceding sections at Marklesburg and other places in central Pennsylvania. As the latter sections are considerably thicker we are probably warranted in concluding that the absence of this zone is due to overlap and resulting loss of beds from the bottom in southwesterly direction.

(2) As the Zygobolba anticostiensis zone, which is clearly indicated at 55 to 60 feet above the base of the Clinton at Cumberland, contains the most characteristic Ostracoda of the purple "Upper" shale (probably = Chadwick's Bear Creek shale) at Rochester, N. Y., the Cumberland section proves that this second zone of the Lower Clinton underlies at least the Middle Clinton Mastigobolbina lata zone of Oneida County, New York, and does not pass into the latter or overlie it as thought by Chadwick.[1] That the third or Zygobolba decora zone of the Lower Clinton also underlies the Mastigobolbina lata zone was already established by the Honey Grove section and is again shown in the section at Cumberland where moreover it underlies the Zygobolbina emaciata zone.

[1] Bull. Geol. Soc. of Amer., vol. xxix, pp. 327-368, 1918.

(3) The Cumberland section corroborates the evidence of the preceding sections, particularly the one at Honey Grove, Pa., in establishing the sequence of ostracod zones here recognized, excepting the lowest which is absent at Cumberland.

CORRELATION OF OSTRACOD ZONES.—The general sequence of the ostracod zones of the Clinton in the Appalachian region of Pennsylvania and Maryland has been reasonably established by the foregoing sections and lists of fossils. It remains to determine as satisfactorily as is now possible the relations of these zones to those worked out in New York and elsewhere in North America. This may be done most advantageously by discussing the several zones in the order of their deposition. However, as the lowest of these zones, namely the Zygobolba erecta zone, is definitely known only in the thickest of the Pennsylvania sections mention of its possible correlate in the Anticosti section is postponed to a succeeding paragraph dealing with the Ostracoda of the basal part of the Gun River formation.

The Zygobolba anticostiensis Zone.—This, the second of the Clinton ostracod zones, is typically developed in the Island of Anticosti where, according to collections made by Schuchert and Twenhofel, it is best expressed in Bed 9, which comprises the upper 100 feet or so of their Gun River formation. The Ostracoda are very well preserved in the mentioned bed and when subjected to critical study proved separable into a number of closely drawn species. The most useful of these for present purposes are six species of Zygobolba, all figured in this work on Plates LXIV and LXV under the names *Zygobolba anticostiensis, Z. rectangularis, Z. excavata, Z. inflata, Z. recurva,* and *Z. twenhofeli.* In New York at least four of these six species occur in the purple shale and included pearly limestones that overlie the Pentamerus oblongus limestone at Rochester. Four of them have been identified also in the lower 65 feet of the Clinton at Cumberland, Md. Still further south, namely at Hagans, near the southwestern extremity of the State of Virginia, five of the six have been found. In Anticosti this association of species occurs in limestone, at Rochester in limestone and shale, at Cumberland in shale and sandstone, at Hagans in shale. At the Virginia locality the Gun River species are found with three other species of the genus—*Z. curta, Z. oblonga,* and *Z. prolixa*—that have not been observed in Anticosti. But the first and second of these additional species are found with the others at Cumberland and the third occurs at Rochester.

At each of these four widely separated localities the Ostraeoda are associated with the typical long-hinged form of *Anoplotheca hemispherica;* and none of the other occurrences of this brachiopod is precisely like this one. Apparently, then, if precise correlation by means of detailed matching of fossils is as feasible as we believe, then we have established the Zygobolba anticostiensis zone as a faunal datum plane extending through eastern America from the Gulf of St. Lawrence to the southwestern corner of Virginia. At the same time we have proved the Lower Clinton age of at least the upper half of the Gun River formation beyond all reasonable doubt.

So far as known the fauna of the Gun River formation contains nothing that is definitely opposed to its assignment as a whole to Lower Clinton time. On the contrary the fossils of even its lowest bed (D 5 of Schuchert and Twenhofel's section) have a decidedly more Clinton than Medinan aspect. Among them we note particularly four or five species of Zygobolba, with species of Apatobolbina, Chilobolbina, Bollia, Primitia, and Bythocypris that seem scarcely if at all distinguishable from species of the mentioned genera found in the upper part of the Jupiter River formation. Only the Zygobolbas are clearly different. All of them are relatively obese forms with sharp, crest-like carinæ, and thus suggest species like *Z. erecta, Z. carinifera,* and *Z. reversa* which are found in Pennsylvania mainly or only in the lowest of the Clinton zones. The fourth reminds very much of *Z. rectangula* and *Z. twenhofeli.* So far as known the genus Zygobolba appears for the first time in the Anticosti section in this basal zone of the Gun River formation.

The Zygobolba decora Zone.—The third ostracod zone of the Clinton, like the second, is typically developed in the Anticosti section where it attains to best expression in Bed E 9, which includes the upper 158 feet of Twenhofel and Schuchert's Jupiter River formation. This bed lies approximately 600 feet above Bed D 9 of the Gun River formation in which the Zygobolba anticostiensis fauna is best displayed. In the Jupiter River formation this zone is characterized by *Zygobolba decora, Z. intermedia, Z. robusta,* and *Chilobolbina billingsi* besides a number of other more simple types of Ostracoda that have not yet been found outside of Anticosti. All three of these species of Zygobolba occur quite as abundantly in the typical Sodus shale near Alton, N. Y., as in the Jupiter River formation. In fact they constitute the known ostracod fauna of the Sodus shale. All three have been recognized also in the Tussey Mountain section at Honey Grove, Pa. At the last place, however, they are associated with three other species of Zygobolba and one of Zygobolbina that so far have not been found outside of the State of Pennsylvania.

As previously remarked, there is some and perhaps sufficient room in the section at Cumberland, Md., for the Zygobolba decora zone, but the characteristic Ostracoda of this zone have so far not been discovered in Maryland nor at any place south of Pennsylvania. Besides, in southwestern Virginia the Mastigobolbina lata zone lies so near beds holding species of the Zygobolba anticostiensis zone that it is difficult to escape the conviction that the Z. decora zone is nearly or wholly lacking in Virginia.

Whenever the ostracods of the Z. decora zone have been found they are associated with particular unnamed varieties of *Anoplotheca hemispherica* that are not precisely duplicated in any of the other Clinton zones. These brachiopod shells may therefore help in identifying this zone.

In Anticosti *Pentamerus oblongus* enters the section in the Gun River formation beneath the Z. anticostiensis zone and ranges upward to the top of the Jupiter River formation. In New York it occurs in two zones—the first in the upper third of the "Reynales" limestone, hence just beneath the Z. anticostiensis zone, the second in the Wolcott limestone which immediately succeeds the Sodus shale that contains the ostracods and varieties of Anoplotheca which mark the Z. decora zone. But *Pentamerus oblongus,* as generally defined, attained very wide geographic distribution and lived through practically the entire time of the Niagaran epoch. Therefore, considering this large brachiopod merely as a specific type, its indexical value in stratigraphic correlation is correspondingly broad. Still, as this shell invaded the continental seas only at certain definitely determinable times—invading sometimes from the east, at other times from the south, and on other mainly later occasions from the north—tracing of any one of these invasions may well lead to very accurate time correlations.

In discussing the locally varying sequence of Clinton formations in New York it was pointed out that the purplish shale which overlies the "Reynales" limestone Pentamerus zone at Rochester contains a typical representation of the Zygobolba anticostiensis fauna, whereas the similar true Sodus shale that lies between this lower Pentamerus zone and the second occurrence of Pentamerus in the true Wolcott limestone contains the most characteristic of the Ostracoda and Anoplothecas of the Zygobolba decora zone. Chadwick in his recent work on the Clinton formations in New York regards these two shales as passing laterally into each other and therefore as the same bed. But their respective faunas are not the same. In fact, as said, the one at Rochester contains highly characteristic Gun River Ostracoda and Brachiopoda, the other has Ostracoda and shells that occur in Anticosti only in the upper part of the Jupiter River formation; and in Anticosti the corresponding faunal zones are separated by 600 feet of calcareous shale and limestone. What happened in New York while this great thickness of limy deposits was being laid down in Anticosti?

Except to say that the process of marine sedimentation must have been interrupted and discontinued for a long time in New York we shall not even try to answer this question. For present purposes it is enough to realize the plain inference that in even the thickest of the Appalachian Clinton sections the Lower Clinton part is far inferior in actual thickness of deposits to the combined thickness—nearly 1000 feet—of the corresponding Gun River and Jupiter River formations. And we should not ignore the fact that the latter formations consist mainly of limestone whereas the others consist mainly or wholly of sandstone and shale. This is only one of literally hundreds of similar instances in American stratigraphy that teach a lesson that might well be taken to heart by those who persistently and blindly strive to destroy or belittle the conception of differential vertical movement of the surface of the lithosphere and deny most of the local breaks in stratigraphic sequences that resulted from their operation.

The ostracod evidence on which formations and faunal zones in Anticosti, New York, Pennsylvania, Maryland, and Virginia are correlated and referred to the Lower Clinton may be graphically summarized in tabular form as follows:

GEOGRAPHIC AND STRATIGRAPHIC DISTRIBUTION OF LOWER CLINTON SPECIES OF ZYGOBOLBA WHICH HAVE BEEN FOUND IN TWO OR MORE WIDELY SEPARATED PLACES

	Z. erecta zone		Z. anticostiensis zone				Z. decora zone		
	Pa.	L G	U G	R	C	H	J	A	Pa.
Z. carinifera	x	?	...	...	...	...	...	...	...
Z. erecta	x	?	...	...	...	...	...	...	...
Z. reversa	x	?	...	...	...	...	...	...	...
Z. anticostiensis	...	...	x	...	x	x	...	...	...
Z. rectangularis	...	?	x	x	x	x	...	...	...
Z. excavata	...	...	x	x	x	x	...	...	...
Z. inflata	...	...	x	x	...	x	...	...	...
Z. recurva	...	...	x	x	...	x	...	...	...
Z. prolixa	...	...	...	x	...	x	...	...	...
Z. oblonga	...	...	...	...	x	x	...	...	...
Z. curta	...	...	...	...	x	x	...	...	...
Z. twenhofeli	...	?	x	...	x	...	...	...	...
Z. decora	...	...	...	...	...	...	x	x	x
Z. intermedia	...	...	...	...	...	...	x	x	?
Z. robusta	...	...	...	...	...	...	x	x	x

Pa. = localities in central Pennsylvania.
L G = lower 50 feet of the Gun River formation, Island of Anticosti.
U G = upper part of the Gun River formation, Island of Anticosti.
R = purple shale above Pentamerus oblongus zone at Rochester, N. Y.
C = 60 feet above base of Clinton at Cumberland, Md.
H = purple shale and iron ore of Lower Clinton at Hagans, Va.
J = upper 50 feet of Jupiter River formation, Island of Anticosti.
A = true Sodus shale, near Alton, N. Y.

The Zygobolbina emaciata Zone.—The typical locality of this zone is in Cove Gap through Cove and Tuscarora mountains along the pike from Mercersburg to McConnellsburg, Pa. Here it consists mainly of rather soft greenish-gray shale with beds of yellow porous sandstone highly fossiliferous and probably originally calcareous. The total thickness of the Clinton at this place is approximately 750 feet and the Z. emaciata zone lies apparently less than 200 feet above the base of the formation.

The following fossils were collected a short distance east of the toll-gate: molds of a ramose bryozoan suggesting a species of *Bythopora, Trematis* n. sp., related to *T. oblata,* two varieties of *Anoplotheca hemispherica, Tentaculites* cf. *minutus, Pterinea* aff. *emacerata,* two species of *Ctenodonta, Cleidophorus* sp., *Cyrtodonta* sp., *Paracyclas* ? n. sp., *Orthodesma* cf. *curtum, Modiolopsis subalatus, Zygosella limula, Zygobolba bimuralis, Zygobolbina emaciata* (exceedingly abundant), *Mastigobolbina declivis, M. lata-nana, M. cf. vanuxemi, M. virginia, Plethobolbina sulcata, Paræchmina postmuralis, Bythocypris* sp. Except the pelecypods these fossils occur in both the shales and the sandstones. The pelecypods are found only in the shale, and this probably explains why they are so rarely seen in weathered natural outcrops.

The most abundant of the ostracods is the *Zygobolbina emaciata.* It occurs here literally by thousands. The species when typically developed and well preserved is easily distinguished by its rather long oblique form, prominent thin U-shape ridge and generally emaciated appearance. Varieties in which the ridge is not so high as it should be occur in Lower Clinton zones. But these are never found in association with species of Mastigobolbina like those cited above. The latter are tending toward characteristic Middle Clinton species like *M. lata* and *M. vanuxemi.* The Zygosella and the Zygobolba also indicate Middle Clinton. On the other hand—considering only known Clinton occurrences—the pelecypods at first sight suggest Lower Clinton. But here again further investigation shows that the zone shares two or three species also with the Drepanellina clarki zone at the very top of the Clinton. Still the total combination of species is different from all other Clinton associations, and being intermediate in character between those that are clearly of Lower Clinton time and those of Upper Clinton facies there is on this ground alone sufficient warrant for placing the zone in the Middle Clinton.

The assignment of the Z. emaciata zone to the base of the Middle Clinton rests primarily on the fact that at Cumberland, Md., the denominating guide fossil occurs abundantly and in typical form in the Cresaptown iron sandstone which underlies beds containing a fairly typical development of the Mastigobolbina lata fauna. In the section on Tuscarora Mountain near Honey Grove, Pennsylvania the Z. emaciata zone lies about 300 feet above the base of the Clinton. At this place only the thin sandstones were available for collecting, and this probably accounts for the absence of the pelecypods, these having been observed elsewhere only in the shales exposed in new road excavations. Finally, the position of the Z. emaciata zone is fixed in the Honey Grove section by the occurrence of the M. lata fauna above it and that of the Zygobolba decora zone beneath.

The Mastigobolbina lata Zone.—The M. lata zone is perhaps the most generally recognized of the Clinton zones in the Appalachian region. In New York its highly characteristic fauna occurs in typical development in Oneida County. The best and most fossiliferous exposures are found to the southwest of Utica in the vicinity of New Hartford. The evidence in hand indicates that the beds which contain this fauna pinch out rapidly to the west of Clinton. They pinch out, apparently by overlap, also to the eastward, in which direction moreover the shales and fine-grained sandstones are largely replaced by coarser clastics. Passing southwardly under younger deposits the zone emerges again in central Pennsylvania. It was clearly recognized on the south side of Jacks Mountain between Lewistown and Reedsville, Mifflin County, where it lies about 325-350 feet above the Tuscarora sandstone. Also at various places on Tussey and Tuscarora mountains, in which sections it lies near the middle of the Clinton. In Maryland it is clearly indicated above the horizon of the Cresaptown iron sandstone at Cumberland. In Virginia its fossils were collected and its position in the section determined 1.5 miles northwest of Warm Springs, 1 mile west of Narrows, at Cumberland Gap, and other places in the State. The band that contains the M. lata zone at Cumberland Gap extends some 30 or 40 miles into Tennessee, and although Clinton fossils of every kind become very rare in that direction *M. lata* was observed near the southern extremity of this extension. Finally, an unmistakable representation of this fauna occurs in Lavender Mountain near Armuchee, Ga. At this place, however, the guide fossils are associated with species that do not accompany them in Virginia, Maryland, and Pennsylvania, and on this account we are inclined to view this Georgia occurrence of the fauna as indicating a separate though contemporaneous invasion from the Atlantic near Savannah.

As usual with Clinton faunas the main guide fossils of this zone are Ostracoda of the family Zygobolbidæ. The most serviceable of these are *Mastigobolbina lata, M. vanuxemi, M. clarkei,* and *Zygobolbina conradi.* All four of these species are found associated on the same slabs in New York, and at least two, often three and sometimes all four were found wherever collections from the M. lata zone were made in Pennsylvania, Maryland, Virginia, and northeastern Tennessee. Undoubtedly, other fossils than Ostracoda are confined to this zone. However, they are not so generally present and their use in correlation, pending their subjection to more detailed investigation than they have yet received, must necessarily be uncertain and hazardous. In the meantime the mentioned Ostracoda serve this purpose very well.

The Zygosella postica Zone.—This zone is not so clearly indicated by its fauna and therefore not so easily recognized as the preceding Mastigobolbina lata zone. However, in the Appalachian area between southern Pennsylvania and southwestern Virginia there is usually a more or less sparingly fossiliferous interval between the well characterized zone with *M. lata* and the first appearance of the Upper Clinton Bonnemaia rudis fauna. Though the Z. postica fauna was not observed in the section at Honey Grove, Pa., there is an ample thickness of beds at the place in the section corresponding to its usual position from which no fossils were procured but in which closer search might have revealed its presence. Loose slabs of sandstone containing *Zygosella postica, Z. brevis, Z. gracilis,* and *Mastigobolbina modesta,* all supposedly characteristic Ostracoda of this zone, together with a peculiar Calymene, *Chonetes* cf. *novascoticus,* and *Homœospira apriniformis,* were found above the range of *Mastigobolbina lata* at Cumberland, Md. *Z. postica* and *Z. gracilis* were found in the proper position also in the section along New River, 1 mile west of Narrows, Va. These collections indicate that the Z. postica zone is distinctly younger than the M. lata zone. But we have other collections—one from Warm Springs, Va., another from Gate City, Va.—that prove either that the two zones locally come so close together as to cause mixture of their respective faunas in collecting or that *Mastigobolbina modesta, Zygosella mimica, Z. gracilis* and even *Z. postica* invaded the Appalachian Valley before the final extinction of *Mastigobolbina lata* and *Zygobolbina conradi* therein. With the material in hand it is impossible to decide between these alternatives.

The Bonnemaia rudis Zone.—The Upper Clinton, as herein determined, begins with the B. rudis zone. Its fauna was first observed in Mulberry Gap, Powell Mountain, 5 miles northwest of Sneedville, Tenn. Here the zone constitutes the top member of the Clinton, being immediately succeeded by the Sneedville limestone of Cayugan age. The beds here being also more profusely fossiliferous and readily accessible than any other of Clinton age then known, the fauna of the zone, especially the Ostracoda, was collected and studied with uncommon thoroughness and determined as follows: *Bonnemaia rudis* (exceedingly abundant), *B. fissa, B. longa, B. obliqua, B. pulchella, B. transita, B. transita-transversa, Zygosella alta, Z. vallata-nodifera, Mastigobolbina typus-prænuntia, M. bifidus.* None of these eleven species are known to occur in any of the older zones, and only the third, fourth, and ninth of the list pass into the succeeding zone. Other localities add *Mastigobolbina micula* and *M. ultima.* In view of the relatively large number of characteristic species the B. rudis zone is at least as easily recognizable as any other of the Clinton zones here distinguished. The large size of most of the species helps materially in distinguishing the zone from those underlying it.

Three of the characteristic species of the zone, including *Bonnemaia rudis,* were found in the Honey Grove, Pa., section 200-250 feet beneath the top of the Clinton. The beds containing these fossils lie more than 200 feet above the highest observed occurrence of *Mastigobolbina lata.* In the opposite direction the first appearance of *M. typus* is nearly 100 feet nearer the top of the group, that is about 150 feet beneath the top.

A piece of sandstone, found by some unknown collector in the vicinity of Cumberland, Md., contains *B. rudis ?, B. longa, B. pulchella, B. obliqua,* and *Mastigobolbina virginia.* This association of species can hardly mean anything else but the B. rudis zone, and may be accepted as reasonably conclusive evidence of the presence of this zone in the Clinton section at

Cumberland. Unfortunately, data are lacking as to the relations of the occurrence to overlying and underlying zones. The zone seems to be represented also in the section at Six Mile House, Md., where *Zygosella vallata-nodifera, Mastigobolbina micula,* and *M. ultima* were found 102 feet beneath the Keefer sandstone or 25 feet beneath the lowest occurrence of *M. typus* which is 77 feet beneath the Keefer.

In Virginia the zone was doubtfully identified at Williamsville, but there is no doubt about its presence in the Clinton section at Big Stone Gap. If it occurs along the strike between Big Stone and Cumberland Gap the fact remains to be established. The Clinton sections in this stretch suggest contemporary oscillation and resulting absence of beds and also considerable erosion of the surface of the Clinton during the following Devonian period. At Hagans, for instance, the Lower Clinton lies scarcely 200 feet beneath the Black shale, with no visible evidence of Upper Clinton beds. To the northeast at Big Stone Gap the B. rudis zone is succeeded by a good development of the Mastigobolbina typus zone and this by Cayugan and Helderbergian limestones and then about 800 feet of Upper Devonian shale. In the opposite direction at Cumberland Gap the B. rudis zone was not recognized, but the succeeding M. typus zone is present though not thick. Over it comes about 450 feet of Mississippian Black shale. Farther southwest along the same strike in Powell Mountain, Tenn., the Clinton is terminated above by a strong development of the B. rudis zone and on this comes first the Sneedville limestone and then Chattanooga shale.

The Mastigobolbina typus Zone.—This zone has a wider and more definitely ascertainable distribution in eastern America than any other of the Clinton zones. It contains a large fauna—apparently 75 species—and by far the majority of these are confined to this zone. However, anything approaching a complete representation of the fauna can be expected or procured only at places in which the zone is uncommonly calcareous with many thin limestone plates. The corals and most of the brachiopods are at least rare and often entirely wanting to the south of Maryland and also in the western part of this state, in which directions the limy facies of the zone, which prevails in central Pennsylvania and extends southward to

Great Cacapon, W. Va., is replaced by siliceous shales and sandstones. The character of the fauna as developed in the calcareous facies is correctly though not completely indicated by the list of species found in this zone in the vicinity of Hollidaysburg, Pa.

Of the 75 species so far collected from the M. typus zone more than 30 are Ostracoda. The latter, fortunately, are less partial to particular kinds of rock than are most of the other classes. Most of the Ostracoda seem also to have been excellent travelers, for we find their remains often in great numbers in the thick and thin sandstones that make up a large part of the Upper Clinton in southwestern Virginia and in the sandy shales of corresponding age in east central Kentucky and southern Ohio. Consequently, we are forced to depend almost entirely on the Ostracoda in recognizing the deposits of this age in the mentioned areas. Even in the calcareous northern phase of the zone we have found it advisable to depend mainly on the Ostracoda without, however, any intention to ignore whatever of help that may be offered by other kinds of fossil remains.

The Brachiopoda of the zone are of value particularly in establishing the Upper Clinton age of the beds. This is accomplished, we believe, beyond question by the presence of *Schuchertella subplana,* the four species of *Spirifer,* the two of *Atrypa,* and the *Nucleospira.* But these species occur also in the Rochester shale in New York and in Maryland and Pennsylvania are found in the Drepanellina clarki zone as well as in the M. typus zone. The case is similar with respect to the five rhynchonelloids; and even *Anoplotheca obsoleta, Chonetes cornutus,* and *Dalmanella elegantula* are represented by scarcely distinguishable mutations in the two zones. The Brachiopoda, therefore, are of as little value in distinguishing the several Upper Clinton zones from each other as they were found to be in separating the Middle and Lower Clinton zones.

Whether the molluscan shells are any better for our purposes is doubtful. To begin with, we know too little about them, either as regards their specific characters or their vertical ranges. Besides, their state of preservation commonly is too unfavorable for precise identification and their occurrence usually too sporadic to fit them for practical guide fossils.

The trilobites probably could be made useful, but no one has yet subjected the Clinton forms to the minutely discriminating investigation required to fully bring out their indexical qualifications. At present all of the Calymenidæ having pygidia with smooth pleural lobes are referred to *Liocalymene clintoni*. But preliminary study of the Clinton trilobites of this genus suggests that the form which occurs in the Mastigobolbina typus zone is not strictly the same as those that are found in the Middle and Lower Clinton. Moreover, the former has not been found above the Keefer sandstone so that it may be set down as one of the characteristic fossils of the M. typus zone. In our experience the presence in American formations of a species of Dalmanites with posteriorly acuminate pygidium is certainly not older than the M. typus zone. Such a species occurs in both the M. typus and Drepanellina zones, and both have been referred by authors to *Dalmanites limulurus*. But the two are not the same, the younger of the two being the true *D. limulurus* whereas the older belongs to an undescribed species with fewer pygidial segments for which the name *Dalmanites clintonensis* is proposed. The latter then also is to be added to the guide fossils of the M. typus zone.

After all, however, it is the Ostracoda that supply the most distinctive and ever-present—therefore the most practical and serviceable—guide fossils of this zone. As already stated, more than 30 species have been determined, and among these are at least nine large species that may be expected at any outcrop of the zone from New York to southwestern Virginia and thence through Kentucky to southern Ohio. These are *Mastigobolbina typus, M. arguta, M. trilobata, M. triplicata, M. punctata, Plethobolbina typicalis, Bonnemaia celsa, B. crassa,* and *Zygosella vallata.* So far as now known all of these nine species are strictly confined to the *M. typus* zone.

To illustrate the geographic distribution and general unity of this ostracod fauna the following lists of species collected at widely separated localities are presented.

At Clinton, N. Y., in 15 feet of shale and thin limestones immediately overlying the oolitic iron ore bed: *Mastigobolbina typus, M. trilobata, M. punctata, Plethobolbina typicalis.*

In the vicinity of Hollidaysburg, Pa., the species cited in the long list given on p. 362 occur in limestones.

In sandstone on Tuscarora Mountain, near Honey Grove, Pa.: *Mastigobolbina typus, Bonnemaia celsa, B. crassa, B. longa, B. perlonga, Zygosella vallata.*

In limestones two miles east of Great Cacapon, W. Va.: *Mastigobolbina typus, M. arguta, M. intermedia, M. triplicata, Plethobolbina typicalis, P. ornata, Bonnemaia crassa, Zygosella vallata, Beyrichia lakemontensis, Æchmina crassa, Dizygopleura loculata, Apatobolbina granifera.*

At Cumberland, Md., in sandstone: *Mastigobolbina typus, M. triplicata, M. virginia, Plethobolbina typicalis, P. cornigera, Bonnemaia celsa, B. crassa.*

At Big Stone Gap, Va., in sandstone: *M. typus, M. arguta, M. virginia, Plethobolbina typicalis, Bonnemaia celsa, B. crassa, B. oblonga.*

In argillaceous and slightly sandy shale in the upper (Estill clay) member of the Alger formation in the western part of Lewis County, Kentucky: *Mastigobolbina typus, M. triplicata, M. trilobata, M. glabra ?, Plethobolbina* sp., *Zygosella vallata.* Associated with these Ostracoda are *Rafinesquina* or *Brachioprion* sp., *Chonetes cornutus, Anoplotheca* cf. *obsoleta, Camarotœchia neglecta ?, C.* sp., *Ctenodonia* 2 sp., *Cyrtodonta* sp., *Bucaniella* aff. *trilobata, Dalmanites clintonensis, Liocalymene* cf. *clintonensis.*

In Adams County, Ohio, in shaly sandstone of the Alger formation, collected by Dr. A. F. Foerste: *M. typus, M. arguta, M. modesta, M. trilobata, M. triplicata, M. punctata, Plethobolbina typicalis, Zygosella vallata;* associated with other fossils similar to those listed from Lewis County, Kentucky.

In comparing these lists the outstanding fact is that all four of the species found at Clinton, N. Y., are among those listed from Lewis County, Kentucky, and those collected by Doctor Foerste from the upper member of the Alger formation ("Niagara shales") in Adams County, Ohio. The absence of one or more of them in some of the other lists doubtless is due to the fact that the time devoted to the making of the collections was in all of such cases very brief. Only the exposures at Hollidaysburg, Pa., were searched with anything like thoroughness. It should be observed also that seven of the eight species that were found in Ohio are included in the list of 25 species that rewarded our efforts at Hollidaysburg to gain a comprehensive conception of the fauna of the M. typus zone. The exception, *Mastigobolbina modesta,* has not been found north of Virginia.

One of the most important features of the present inquiry is the determination of the presence of the M. typus zone at Clinton, N. Y., and how much of the section at that place should be correlated with it. As stated in the discussion of the New York Clinton sections the oolitic iron ore and the 18 feet of shale and thin limestones over it in the section at Clinton are regarded as corresponding to the M. typus zone of the Appalachian Valley. This conclusion is based primarily on the presence of at least four of the most characteristic Ostracoda of the M. typus zone in the mentioned beds at Clinton. But there is considerable other faunal evidence to support the testimony offered by the ostracods; and it is rendered all the more probable by the fact that this correlation fits in very well with views advocated here respecting the relations of preceding and succeeding Clinton formations or zones in the concerned regions.

The shales interbedded with and directly overlying the oolitic iron ore at Clinton, N. Y., have yielded a fauna of nearly 50 species. Unfortunately, many of these species cannot be cited specifically, being unnamed. Some of them also require closer investigation before their stratigraphic significance is clearly established. Still the following lists include besides the Ostracoda many brachiopods, pelecypods, and trilobites that tend to prove at least that the oolitic iron ore is not older than the M. typus zone. Moreover, a few of them must be accepted as offering positive corroboration of the testimony of the Ostracoda that Beds 4 and 5 of the section at Clinton are of the same age as the M. typus zone of central Pennsylvania and Maryland.

FOSSILS FROM THE SHALE REMOVED IN MINING OF OOLITIC IRON ORE AT CLINTON, N. Y.

Roots of Eucalyptocrinus
w Ischadites n. sp.
w Monograptus clintoni
Dendrograptus rectus
Cactograptus crassus
Paleodictyota bella
P. clintonensis
Cyclograptus rotadentatus
Dictyonema retiformis
Paleschara sp.
Helopora aff. fragilis
n Lingula lamellata
L. n. sp. (surface beautifully spinose)
m r Plectambonites transversalis
Brachioprion ? sp.
m Leptæna rhomboidalis
r Schuchertella subplana
m Chonetes cornutus
m Anoplotheca obsoleta
m r Atrypina disparilis
m r Eospirifer radiatus
m Camarotœchia aff. indianensis
m r Camarotœchia neglecta
m r Pterinea emacerata
r Posidonomya ? rhomboidea ?
Modiolopsis sp. nov.
m Ctenodonta cf. elliptica
Cleidophorus sp.
Whitella sp. cf. Avicula ? orbiculata)
Rhytimya sp. nov. (1)
R. sp. nov. (2)
Cuneamya sp. nov. (aff. C. scapha)
Loxonema sp.
Seelya aff. loydii
Hyolithus sp.
r Dawsonoceras annulatum
Arabellites
Serpulites (aff. S. dissolutus)
m Mastigobolbina typus
m Mastigobolbina trilobata
m Mastigobolbina punctata
m Plethobolbina typicalis
m Liocalymene clintoni
m Dalmanites clintonensis

FOSSILS FROM THE PALÆOCYCLUS LAYER LESS THAN 10 FEET ABOVE THE OOLITIC IRON ORE AT SAME PLACE

m Palæocyclus rotuloides
Eridotrypa sp.
Phænopora cf. canadensis
Helopora aff. fragilis
m r Dalmanella elegantula
m r Nucleospira pisiformis
And the four ostracods of the preceding list

Of the above lists, aggregating 50 species, 16 are preceded by the letter m, indicating that the species so marked occurs also in the Mastigobolbina typus zone in Pennsylvania and Maryland. Of the remaining 34 species we may disregard all the graptolites and most of the pelecypods and other mollusks because these are found only in the soft freshly excavated shale at Clinton, which type of rock was not available for collecting at any of the natural outcrops of the M. typus zone searched for fossils in the states to the south of New York. For similar reason we would eliminate also the Ischadites, the two Lingulas, and the Serpulites. With these eliminations, aggregating about 22 species, the remaining species of the two lists constitute a fairly normal Mastigobolbina typus fauna.

In earlier discussions of the age of the beds associated with the oolitic iron ore at Clinton and of their unquestioned correlate, the Mastigobolbina typus zone, in Maryland the strongly expressed similarity of the faunas to that of the Rochester shale (species preceded by the letter r) seemed so striking that correlation with the latter appeared unavoidable. This apparent Rochester alliance is particularly notable in comparing the brachiopods which constitute the most conspicuous element of the fauna in the limy facies of the M. typus zone. Among these are *Pholidops squamiformis, Dalmanella elegantula, Schuchertella subplana, Plectambonites transversalis, Spirifer bicostatus, S. eudora, S. niagarensis, S. radiatus, Atrypa reticularis, A. nodostriatus, Atrypina disparilis, Nucleospira pisiformis* and species of *Camarotœchia* that are scarcely distinguishable from *C. acinus, C. indianensis, C. bidentata*, and *C. neglecta*. Practically all of these shells are typically represented in the fauna of the Rochester shale; and this relationship was further emphasized before we learned to distinguish the *Dalmanites* that occurs with them in the M. typus zone in Maryland and Pennsylvania and in the oolitic iron ore at Clinton from the true *D. limulurus* of the Rochester shale.

However, since those earlier conclusions much evidence has accumulated tending to establish the now accepted fact that the presence of the mentioned brachiopods in the M. typus zone signifies merely a preceding invasion of species previously believed to be indicative of the Rochester age. Even in New York most of them are now known to range down into the reefy bed at the top of the Irondequoit limestone; and some of them occur also in the Williamson shale. The last occurrence, as stated before, doubtless corresponds to the one at Clinton and both of these to that in the M. typus zone in Maryland. One of the best pieces of evidence favoring the latter correlation, and which has not yet been brought out as it deserves, concerns the coral *Palæocyclus rotuloides*. This peculiar fossil was originally described from specimens found at Clinton, N. Y., where it is confined to a thin bed lying a few feet above the oolitic ore. The same coral occurs in the lower half of the M. typus zone at Hollidaysburg, Pa.

Here also it is confined to a single layer of limestone less than a foot thick. No reason is known why these two occurrences should not be accepted as strictly contemporaneous.

Nearly if not quite as valuable as the coral and the Ostracoda in proving the essential contemporaneity of these beds is the *Chonetes cornutus*, the *Anoplotheca obsoleta*, the *Liocalymene clintonensis* (s. st.), and the *Dalmanites clintonensis*. All of these are represented by precisely the same varieties in the two beds.

The Keefer Sandstone and Supposed Equivalents in Pennsylvania and New York.—The Keefer sandstone varies considerably in thickness and character from place to place in Maryland. Evidently some oscillation and land elevation occurred at this time, and these movements increased the supply of clastic material. The Keefer is 11 feet thick at Cumberland, about 40 feet thick near Hancock, and somewhat less than 25 feet thick in North Mountain. The evidence in hand suggests that this sandstone member is little more than a lithologic facies that toward the east, as in North Mountain, possibly covers the whole of Upper Clinton time. Its position is usually indicated in the Clinton sections in Pennsylvania, and a bed regarded as marking the same time is so designated in the section at Clinton, N. Y. A sandy and ferruginous limestone in the section at Hollidaysburg, Pa., is referred to this zone. In the Honey Grove section the same zone is represented by a rather coarse grained sandstone.

Except in the vicinity of Flintstone fossils are not commonly found in the Keefer in Maryland. Stose, in 1910, found some remains of Eurypteridæ in a black shale interbedded with the sandstone a few miles west of Hancock. These suggested Cayugan species of Hughmilleria and Pterygotus, and it was on this, then supposedly determinative evidence, that the Keefer was erroneously placed at the base of the McKenzie formation and with it in the Cayugan epoch of the Silurian.

No list of the fossils found in the Keefer sandstone at Flintstone is available, so we cannot say whether they are more closely allied to the overlying or the underlying fauna. Perhaps their relations are no more decisive than are those of the 6 species procured from this bed at Honey Grove, Pa., listed on p. 353. Still, three of the brachiopods at the latter place, *Rhipidomella* cf. *hybrida, Spirifer crispus,* and *Camarotœchia* cf. *plicatella,* and the *Dizygopleura* lean toward the succeeding fauna rather than the preceding.

In describing the section at Clinton, N. Y., beds 6 and 7 of the section are said to "probably correspond to the Irondequoit limestone at Rochester and to the Keefer sandstone of Maryland and Pennsylvania." This view is suggested primarily by the fact that these beds follow shaly layers containing the Mastigobolbina typus fauna and are overlain by the red flux iron ore bed which is filled with Rochester Bryozoa. The zone thus occupies the position of the Keefer. The few fossils found in it at Clinton throw no definite light on the question, but at the same time they offer nothing opposing the suggested correlation.

No Ostracoda were found in the supposed Keefer representative at Clinton. But fossils of this class were procured from the Irondequoit limestone. The senior author, namely, collected at least six species of Ostracoda out of a block of Irondequoit limestone found about 8 miles east of Lockport. One of these species, *Beyrichia hartnageli,* is described and figured in this volume. The others comprise a species of *Klœdenella,* a *Dizygopleura* (allied to *D. proutyi* and *D. pricei* of the Drepanellina clarki zone in Maryland but a clearly distinct new species), a *Thlipsura* and two species of *Bythocypris.* Except the last, which are too simple in structure to be of value in refined stratigraphic correlation, none of these Ostracoda is precisely like any of the Silurian species found in Maryland. But they are all of Atlantic types and so must have invaded New York from the east or southeast. Then, as these species have not been found in the Upper Clinton of either Maryland or Pennsylvania, they could hardly have passed through here without leaving fossil traces of their line of migration except during the deposition of the Keefer.

By comparison of these Irondequoit Ostracoda with their relatives in Appalachian formations we are again led to the conclusion that the Irondequoit probably correlates with the Keefer. Thus, the *Beyrichia hartnageli* is intermediate in its characters between *B. lakemontensis,* a species of the M. typus zone, and *B. veronica* or *B. normalis,* both of which belong to the Drepanellina clarki fauna. The inturning of the dorsal extremity of the posterior lobe is a primitive character that is still well developed in *B. hartnageli* but is almost entirely lost in *B. veronica* and *B. normalis*. As for the new *Dizygopleura* it might well represent an antecedent stage in the development of a species like *D. pricei*. Finally, *Thlipsura* is a British Silurian genus that is otherwise wholly unknown in American deposits of this period. We had expected to find species of this peculiar genus in the Appalachian Silurian formations, but our search for American representatives of this age proved unavailing except in this single block of Irondequoit limestone.

The Drepanellina clarki Zone.—This is the highest of the Clinton zones in Maryland and Pennsylvania and in our opinion is the only part of the Appalachian facies of the Clinton that we feel warranted in correlating with the Rochester shale. Some of the reasons for this conclusion were given in the preceding discussion of the Clinton sections in New York. In our argument trying to establish our view that the invading Atlantic and southern seas and faunas of this time actually intermingled in Pennsylvania and New York we also endeavored to explain why only a few of the southern invaders reached Maryland. It appears, in fact, that the Rochester element in the Drepanellina clarki zone in Maryland and Pennsylvania is made up very largely of species that migrated to western New York from the east. Much the greater part of the southern element, especially the Bryozoa, in the Rochester fauna, on the contrary, dropped out of the race very soon after passing Rochester. Only a few remain at Clinton, N. Y., and hardly any reached central Pennsylvania and Maryland.

METHODS OF CORRELATION.—Facts like the above show the absolute futility and error of trying to correlate formations of distinct provinces by the percentage method of faunal comparison. In the present case the fauna of the Appalachian zone that we regard as corresponding in age to the Rochester shale of New York comprises only a small percentage of the species found in the Rochester at Lockport, N. Y.; and even this minor part is largely made up of species that as now defined are known to have a wide geographic and long vertical range. Most of the latter, and this includes more than three-fourths of the brachiopods and mollusks, are

Upper Clinton or even Niagaran fossils and not only Rochester species. Closer study of these long-ranging species probably would result in their separation into distinguishable mutations, each of which would be characteristic of only one of the several divisions of the Upper Clinton. But this requires many and uncommonly good specimens and much work that remains as yet to be done. We need also to learn where they were raised and what paths they followed to get to the places where their remains are now to be found.

Something approaching the comprehensive investigation required to render such fossils of value in detailed correlation has been given to the Silurian Ostracoda. Also to the Dalmanites and a few other species of this zone that happened to belong to genera which have been subjected to close study. On the principle of correlation by minute structural comparison and identification of biologically non-essential features[1] only a few of such completely similar forms held in common by formations of distinct provinces are required to establish the practical contemporaneity of the beds holding them. Therefore, although the Atlantic species that migrated as far west as Niagara Falls constitute less than 10 per cent of the total Rochester fauna and the southern species that passed on from western New York into the Appalachian province are so few, if any, as to be almost negligible, we may yet accomplish the correlation of the Rochester shale and the Drepanellina clarki zone with reasonable confidence and certainty.

The first step in this correlation was already taken when in the preceding discussion of the Clinton of New York the species of Rochester Bryozoa in the red flux ore bed, which overlies the correlates of the Keefer sandstone and the Mastigobolbina typus zone in the section at Clinton, were enumerated. Anyone who would deny the Rochester age of the red flux ore bed must either disprove the identification of the Bryozoa or ignore their testimony entirely.

The second step is accomplished by noting the presence of Ostracoda belonging to the Appalachian and Atlantic faunas of the time in the

[1] Ulrich, E. O., Correlation by displacements of the strand-line: Bull. Geol. Soc. America, vol. xxvii, p. 488, 1916.

typical outcrops of the Rochester shale. Evidently communication between the Atlantic and Southern waters across northern Pennsylvania was far from free and open. The barrier between the two must yet have been pretty effective because we know of only three of the Appalachian Beyrichiacea that reached Lockport, N. Y. These are *Paraechmina spinosa*, *P. abnormis*, and *Dizygopleura symmetrica*. The Rochester shale contains at least four other Ostracoda, but three of these are Cypridæ which occurred in both seas at this time and are too simple in structure to be of use in correlation. The fourth is a *Ctenobolbina*, a southern type, that is unknown in either Silurian or Ordovician Appalachian faunas.

Three of the trilobites of the Drepanellina clarki zone seem to be precisely like species found in the Rochester. One of these is the *Calymene niagarensis*, which perhaps is not so worthy of confidence as a guide fossil as is either the second, *Homalonotus delphinocephalus*, or the third, *Dalmanites limulurus*. All three of these trilobites are represented by closely allied species or varieties in the underlying Mastigobolbina typus zone. But the latter are not precisely like the Rochester types of the species, whereas those found in the Drepanellina zone seem to agree in every detail.

About 25 species of Brachiopoda occur in the Drepanellina zone. Eight of these are described as new species in this volume by Professors Prouty and Swartz. With two or three exceptions the remainder of the list consists of species that have not been distinguished from Rochester fossils. Many of the latter have been studied also by the writers with the result that we also failed to discover satisfactory differences by which the Maryland and Pennsylvania specimens might be distinguished from those found in the Rochester shale of western New York. This striking similarity in the brachiopods of the two formations might then be accepted as strong confirmation of the preceding seemingly weaker evidence of the trilobites and ostracods. But we must not overlook the fact that the majority of these brachiopods are widely distributed and mostly long-ranging species that not only occur also in the Mastigobolbina typus zone in Maryland and in the Irondequoit limestone in New York but have closely allied ancestors in yet earlier Clinton and even late Medinan formations. Still, some of these shells that are common to the Drepanellina zone and the Rochester shale have so far not been found in beds known to be older than the Rochester. Of these the most noteworthy, perhaps, are *Rhipidomella hybrida*, a particular variety of *Atrypa reticularis, Spirifer crispus, Trematospira camura*, and *Whitfieldella oblata*.

OSTRACODS OF THE BISHER DOLOMITE.—Very unexpectedly we receive further light on this perplexing correlation problem from Ohio. Recently the senior author made the fortunate discovery of a considerable ostracod fauna in the Bisher member of the West Union formation in Adams and Highland counties, Ohio. These Ostracoda occur in thin lenses of white chert developed in a fine-grained dolomitic matrix; and most of them are in a fine state of preservation. Among them we recognize *Dizygopleura lacunosa*, the typical and other varieties of *D. symmetrica, D. asymmetrica, D. loculosa, Paræchmina spinosa*, and *Primitiella æquilateralis*, all of which are described in this volume as characteristic fossils in Maryland and Pennsylvania of the uppermost shaly calcareous beds of the Clinton group to which we have applied the term Drepanellina clarki zone.

This close agreement in ostracod faunal contents between the Bisher of Ohio and the Drepanellina clarki zone of the Clinton as developed in the middle Appalachian region carry much weight in deciding the age relations of the Ohio formation to the generalized time scale of the Silurian in America. It is significant further to note that the evidence of the Ostracoda in this case is in essential agreement with that of the associated other classes of fossils. The Bisher fauna of southern Ohio and Lewis County, Kentucky, aggregating, exclusive of the Ostracoda, 45 species, has been listed and discussed by Foerste [1] as follows:

"An approximate correlation of the Bisher member with Niagaran strata in New York State is made possible by the fact that the upper part of the Crab Orchard shale, which lies immediately beneath the Bisher member, contains *Liocalymene clintoni, Beyrichia lata*, and other fossils occurring in the middle part of the typical Clinton section of New York.

[1] Foerste, A. F., Silurian fossils from Ohio, with notes on related species from other horizons: The Ohio Journal of Science, vol. xix, p. 374, 1919.

In the overlying Irondequoit limestone, however, at the top of the Clinton of New York, occur numerous species found also in the Bisher member, including *Cornulites clintoni, Orthis flabellites, Spirifer radiatus, Rhynchotreta americana, Whitfieldella cylindrica, Anastrophia interplicata, Stephanocrinus gemmiformis, Trimerus delphinocephalus* and *Bumastus ioxus.* Provisionally, therefore, the Bisher member is correlated with the Irondequoit limestone of New York."

On the preceding page Foerste tentatively correlates the Bisher with the Osgood limestone of Indiana.

The present writers in dissenting from Foerste's view just quoted would point out (1) that the *Liocalymene clintoni* and the "*Beyrichia lata*" (*Mastigobolbina triplicata* (Foerste)) of the upper part of the Crab Orchard shale are not the Middle Clinton forms of New York but the Upper Clinton species that are confined to the Mastigobolbina typus zone in Virginia, Maryland, Pennsylvania, and at Clinton, N. Y.; (2) that with possibly one or two exceptions the fossils mentioned in the latter half of the quotation are found in the Rochester shale as well as in the Irondequoit limestone; and (3) that many of the other fossils given in the full Bisher list published by Foerste on p. 369 of the cited paper agree, like the previously mentioned Ostracoda, perfectly with species found in the Drepanellina zone in Maryland. On these grounds, then, we are thoroughly convinced of the contemporaneity of the Bisher member of the West Union formation of Ohio and the Drepanellina zone of Maryland and Pennsylvania; and it follows that the preceding arguments advocating correlation of the Drepanellina zone with the Rochester apply with equal force in the case of the Bisher. Regarding the Osgood limestone of Indiana it is well known that we long ago favored its correlation with the Rochester. Also that we are now thoroughly in accord with Foerste in referring the Osgood and the Bisher to the same stratigraphic plane.

The faunal agreement between the Osgood on the one hand and the Bisher and Drepanellina zone on the other is, as noted by Foerste, very weak. But we see good reason for this weakness in the probable fact that the Bisher and the Osgood were laid down in separate troughs that communicated only in northern Pennsylvania. The Bisher fauna consists mainly of Atlantic invaders that traveled southwestward in their own bay from, say, Cumberland, Md., through West Virginia and northeastern Kentucky to Adams and adjoining counties in Ohio. The southern fauna of the Osgood limestone and the Rochester shale on the contrary is believed to have traveled northeastward from Indiana around the north side of the Cincinnati dome to western New York by way of a trough beneath the northern part of the Ohio coal measures. The two faunas are supposed to have intermingled in western Pennsylvania, making it possible for a few stragglers of the Osgood fauna to reach the head of the Drepanellina clarki bay in south-central Ohio. These separate troughs and bays are indicated in the concerned paleogeographic map on another page.

Our main objection to the view that the Bisher and consequently also its unquestionable correlate, the Drepanellina zone of Maryland and Pennsylvania, are to be assigned to the age of the Irondequoit limestone of New York rests on the fact that the Ostracoda of the Irondequoit, though generically the same, are in no instance precisely the same as their congeners in either the D. clarki zone or in the Bisher. On the other hand, two of the Rochester Ostracoda, namely, *Dizygopleura symmetrica* and *Paræchmina spinosa,* are represented by exactly similar specimens in both the Bisher and the D. clarki zone.

SYSTEMATIC PALEONTOLOGY

SILURIAN

COELENTERATA................C. K. SWARTZ AND W. F. PROUTY
VERMES......................W. F. PROUTY AND C. K. SWARTZ
BRYOZOA..................................R. S. BASSLER
BRACHIOPODA.................W. F. PROUTY AND C. K. SWARTZ
MOLLUSCA.
    PELECYPODA..............C. K. SWARTZ AND W. F. PROUTY
    GASTROPODA..............C. K. SWARTZ AND W. F. PROUTY
    CEPHALOPODA.............C. K. SWARTZ AND W. F. PROUTY
ARTHROPODA.
    OSTRACODA...............E. O. ULRICH AND R. S. BASSLER
    TRILOBITA...............C. K. SWARTZ AND W. F. PROUTY
    MEROSTOMATA..........................C. K. SWARTZ

PLANTAE (?)

CLASS ALGAE

Genus BUTHOTREPHIS Hall

BUTHOTREPHIS GRACILIS var. INTERMEDIA Hall

Plate IX, Fig. 1

Buthotrephis gracilis var. *intermedia* Hall (?), 1852, Pal. N. Y., vol. ii, p. 19, pl. v, figs. 2a, b.

Dendrograptus gracillimum var. *intermedia*, 1885, Jour. Cin. Soc. Nat. Hist., vol. vii, p. 161.

Description.—" Slender, flexible; branches diverging, often simple and much elongated, of the same width as the main stipe."—Hall, 1852.

Most of the branches overlap so much as to make it rather difficult to follow out any individual, however, the general size, proportions and termination ally it with *intermedia.*

Usual width of branch, about 2 mm.

Occurrence.—McKENZIE FORMATION. Pinto, Cumberland, Flintstone. ROCHESTER FORMATION. East of Tonoloway. ROSE HILL FORMATION. In the middle beds of the formation throughout the Maryland area.

Collection.—Maryland Geological Survey.

COELENTERATA

CLASS ANTHOZOA

Subclass HEXACORALLA

Order MADREPORARIA

Suborder TABULATA

Family FAVOSITIDAE

Genus FAVOSITES Lamarck

FAVOSITES NIAGARENSIS Hall[1]

Plate IX, Figs. 2-8

Favosites niagarensis Hall, 1852, Pal. N. Y., vol. ii, p. 125, pl. xxxivA, figs. 4a-h.

Favosites niagarensis Nicholson, 1873, Canadian Jour., n. s., vol. xiv, p. 40.

Favosites niagarensis Lambe, 1899, Cont. Pal. Geol. Survey Canada, vol. iv, pt. i, p. 7.

Favosites niagarensis Grabau and Shimer, 1906, N. Amer. Index Fossils, vol. i, p. 85.

Description.—" Spheroidal or irregular form, rapidly increasing by interstitial cells; walls of cells usually thin, pierced by two rows of minute pores; transverse septa thin, often oblique or bent downwards."—Hall, 1852.

The coralla of the Maryland specimens are irregular in shape, although usually subhemispherical to clavate. The corallites vary from .5 mm. to 2 mm. in diameter, the average size being about 1 mm.; walls of corallites thin, mural pores in one or two rows, tabulæ transverse, entire, their average distance approximating .5 mm., though the latter feature is very variable.

Three closely related forms have been described, *F. niagarensis* Hall from the Lockport limestone, *F. helderbergiæ* Hall from the Coeymans of New York, *F. helderbergiæ* var. *præcedens* Schuchert from the Cobleskill of New York, and Keyser limestone of Maryland. It seems probable that they constitute but one species. Hall comments on the similarity of

[1] For the extended synonymy of this species see Bassler, U. S. Nat. Mus., Bull. No. 92, vol. i, 1915, p. 533.

F. helderbergiæ to *F. niagarensis,* and states that the latter differs in having more numerous diaphragms and in bearing the mural pores on the lateral faces instead of near the angles of the cells. As Lambe (*op. cit.*), however, states, Hall's figures of *F. niagarensis* show that the distance of tabulæ is very variable, while his illustrations show the mural pores in the same position as in *F. helderbergiæ.* The difference, therefore, resolves itself into the more irregular shape of the corallum, somewhat greater average distance of tabulæ and difference in stratigraphic horizons. Of these the manner of growth would appear the chief difference, the specific value of which may be questioned. The variety *F. helderbergiæ* var. *præcedens* Schuchert is characterized by the marked irregularity of the form of the coralla. *F. niagarensis* is intermediate in this respect between *F. helderbergiæ* and the variety *præcedens.*

This species occurs in the *Stenochisma lamellata* zone of the Tonoloway formation. The specimens from the McKenzie formation are somewhat questionably referred to the same species.

Diameter of corallum, 100 mm.; in larger specimens, usually less.

Occurrence.—TONOLOWAY FORMATION. Keyser, West Virginia. McKENZIE FORMATION. Rose Hill, Cedar Cliff, Maryland.

Collection.—Maryland Geological Survey.

FAVOSITES MARYLANDICUS Prouty n. sp.

Plate X, Figs. 4, 5

Description.—Corallum dendroid, branching irregularly, branches compressed to subcylindrical. Corallites varying greatly in diameter in the same corallum, smaller corallites being interspersed with the larger so that some of the latter appear almost circular in cross-section. Corallites prismatic, ascending along the axes of the branches and bending outward towards the surface which they meet obliquely. Tabulæ distant from one-half to one and one-half times the diameter of the tubes, being more remote in the axis and closer towards the surface of the corallum. Mural pores not observed.

This species differs from *F. helderbergiæ* var. *præcedens* in the marked inequality of its corallites. It resembles *F. forbesi* in the latter feature, but differs from it in its irregular form. It differs in both these respects from *F. niagarensis*.

Diameter of corallites, .75 mm. to 2 mm.; diameter of corallum, 25 mm.

Occurrence.—McKENZIE FORMATION. Cedar Cliff, 70 to 90 feet below the top of the formation.

Collection.—Maryland Geological Survey.

FAVOSITES sp.

Plate X, Figs. 1-3

Description.—Corallum subconical, its base covered by a wrinkled epithelium, attached by a small critical point. Corallites prismatic, polygonal, subequal in size, united by thin walls; their interior is striated longitudinally by about 12 linear shallow furrows; spaces between furrows convex; beset within by many small spinous processes. Walls of corallites pierced by large mural pores which are irregularly placed or are arranged in one or two lines on sides of tubes. Tabulæ apparently distant, not clearly preserved in casts observed.

This species is represented by casts of interiors of corallites only.

Diameter of corallum, .25 mm.; diameter of corallites, 1.5 mm. to 2.5 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland, Six-mile House, Flintstone.

Collection.—Maryland Geological Survey.

Family AULOPORIDAE

Genus AULOPORA Goldfuss

AULOPORA TONOLOWAYENSIS Swartz n. sp.

Plate X, Figs. 6, 7

Description.—Corallum consisting of elongate tubular cells, which gradually increase in diameter to apertures; calyces circular, ascending obliquely or at right angles to the tubes; exterior annulated by fine striations. The tubes branch repeatedly, being usually dichotomous, though two branches spring in many cases from the base of a calyx. The walls of the branches often fuse to make a close irregular network. This species is attached to a host, usually *Stromatopora constellata*.

This species is very close to *A. schucherti* of the Keyser limestone, differing chiefly in the somewhat more open network, due to less frequent fusion of the walls of neighboring branches, a difference of uncertain value. The resemblance of the species is close.

Diameter of calyces, 1 mm.

Occurrence.—TONOLOWAY FORMATION. In *Stenochisma lamellata* zone, Keyser-Heddenville road, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

CLASS HYDROZOA

Subclass STROMATOPOROIDEA

Section MILLEPORIDAE

Family STROMATOPOROIDAE

Genus STROMATOPORA Goldfuss

STROMATOPORA CONSTELLATA Hall[1]

Plate X, Figs. 8, 9

Stromatopora constellata Hall, 1852, Pal. N. Y., vol. ii, p. 324, pl. lxxii, figs. 2, 2a, 2b.

Stromatopora concentrica Hall, 1852, Pal. N. Y., vol. ii, pl. lxxiii, figs. 2, 2a, 2b.

Stromatopora concentrica Nicholson, 1875, Rept. Pal. Prov. Ontario, pt. ii, p. 63.

Coenostroma constellatum Miller, 1889, N. A. Geol. Pal., p. 157, fig. 100.

Coenostroma constellatum Nicholson, 1891, Mon. British Strom. Pal. Soc., 1891, p. 173.

Stromatopora hudsonica Nicholson, 1891, *Ibid.*, p. 172.

Stromatopora constellata Parks, 1908, Univ. Toronto Studies, Geol. Series, No. 5, p. 44, pl. xiii, figs. 7, 8, 10.

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[1] For the extended synonymy of this species see Bassler, U. S. Nat. Mus., Bull. No. 92, vol. ii, 1915, p. 1215.

Stromatopora constellata Parks, 1909, Univ. Toronto Studies, Geol. Series, No. 6, pp. 41, 46, pl. xvii, figs. 10, 11; pl. xviii, fig. 8.

Stromatopora constellata Swartz, 1913, Md. Geol. Survey, Lower Dev., p. 221, pl. xxvii, figs. 1-6; pl. xxviii, figs. 1-2; pl. xxix; pl. xxx, fig. 1.

Description.—"Massive, hemispheric, spheroidal or irregular; composed of thin concentric layers, which are penetrated by minute vertical tubes or cells; surface of layers nodose, each elevation being marked by an irregular stellate impression with undulating and bifurcating rays; intermediate spaces smooth, or having only the minute cell apertures. This species presents no important characters to distinguish it from the *S. concentrica,* except the uneven surface of the laminæ, and the stellate impressions upon these elevations. The size of the minute cell is apparently the same as in *S. concentrica;* and in such specimens as break only vertically there is no positive means of distinguishing this species beyond the undulations of the lamellæ which correspond to the uneven surface. It seems, indeed, probable that it may be only a variety of the *S. concentrica,* presenting this peculiarity in its mode of growth."—Hall, 1851.

The species is further described by Parks as follows: "Cœnosteum massive, hemispheric, spheroidal or irregular. The commonest type is hemispheric, and in this form the species reaches a large size, possibly a foot or more in diameter. Latilaminar structure distinct, but the latilaminæ vary greatly in thickness. Exfoliation easy, presenting smooth or gently undulating surfaces. Small, low, rounded mamelons may be present or absent; when present they are situated about 5 mm. apart. Small astrorhizal systems appear on nearly all surfaces, even where no other structure is observable; they are very small—not more than 2 mm. in diameter—and with very few branches. The spacing of these systems is extremely variable—from 3 mm. to 6 mm. or 7 mm. As I have already stated, the distribution of astrorhizæ is of little or no diagnostic value. In the variety with mamelons, the astrorhizæ generally coincide in position with these eminences, but even this is not rigidly true. The skeletal matter consists of radial pillars and concentric laminæ, which are intimately fused, but not sufficiently so to obliterate their individuality. On an average seven pillars appear in a distance of 1 mm. The skeletal matter is rather coarsely porous.

"Vertical sections show the vertical and horizontal elements forming a network with relatively thick meshes. The cut ends of the astrorhizal canals are apparent as interspaces of a more or less rounded character, and the zooidal pores as minute tabulate tubes between the pillars. When the section is thick the laminæ are most pronounced and continuous, because the zooidal tubes are of such small caliber that the section exceeds them in thickness; the thinner the section the more zooidal tubes are seen to hold their course through the laminæ. This is an obvious fact, but one must remember it, or there is grave danger of misinterpretation.

"Tangential sections show the astrorhizal canals as prominent features, and the minute round orifices representing the cross-section of the zooidal pores."—Parks, 1908.

The specimens found in the Tonoloway closely resemble a form described by the author[1] as type C from the Keyser limestone member of the Helderberg formation of Maryland, characterized by possessing very large intricately branched astrorhizæ which may attain a diameter of nearly a centimeter.

The Tonoloway specimens do not show distinctly the finely reticulated fiber as do those from the Keyser limestone, a difference probably due to their state of preservation. In other respects the resemblance is very close. Some cœnostea are a foot in diameter.

This species occurs sparingly in the *Stenochisma lamellata* zone at Keyser, West Virginia. It is abundant in the vicinity of Hancock, where it forms an extensive reef in the middle of the Tonoloway. It is an abundant species in the Niagaran at many localities in North America.

Occurrence.—TONOLOWAY FORMATION. Hancock, Maryland; Keyser, Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

[1] Swartz, C. K., Lower Devonian of Md., Md. Geol. Survey, 1913, p. 223.

VERMES

CLASS CHAETOPODA

Order TUBICOLA

Genus CORNULITES Schlotheim

CORNULITES CONCAVUS Prouty n. sp.

Plate XI, Figs. 1-4

Description.—Somewhat curved, slowly and uniformly attenuate with a consequent small apical angle; rings frequent, contracting toward their base at first more rapidly, giving a concave outline to their periphery; surface of shell where present marked by transverse striæ, which are crossed by somewhat finer longitudinal striæ.

Most of the specimens are internal casts, in part only preserving the wall of the tube.

The species differs from *C. flexuosus* Hall (= *C. clintoni* Hall) in its more numerous annulations, smaller apical angle and more concave lateral outline of its rings. In the number of its annulations it resembles *C. arcuatus* Conrad of the Guelph fauna, but differs from this in its even and less rapid attenuation, greater basal contraction, and in the concave outline of its rings.

Two specimens show the following dimensions: Length, 24 mm.; diameter, 6 mm.; and length, 35 mm.; diameter, 8.5 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland.

Collection.—Maryland Geological Survey.

CORNULITES ROSEHILLENSIS Prouty n. sp.

Plate XI, Fig. 5

Description.—Shell curved, moderately attenuated; rings frequent, obtusely and nearly uniformly rounded. This form resembles *C. arcuatus* Conrad, but has rings more evenly rounded and no angular upper edge.

Specimens observed are casts which bear two or three longitudinal, impressed hairlike lines which are broken at intervals by lateral offsets.

These lines often run at an angle to the axis of the shell. In the character of these lines the species resembles *C. serpularius* from the Wenlock.

Length, 26 mm.; diameter at large end of exfoliated form, 7 mm.

Occurrence.—ROCHESTER FORMATION. Pinto, Rose Hill, Cumberland, Maryland; Great Cacapon, West Virginia. ROSE HILL FORMATION. Pinto, Cumberland, Cresaptown, just below the lower "iron-ore" bed, Maryland.

Collection.—Maryland Geological Survey.

CORNULITES CANCELLATUS Prouty n. sp.

Plate XI, Figs. 6, 7

Description.—Shell conical, tapering very gradually, annulated by broad shallow constrictions placed at intervals about equal to the diameter of the shell. Surface ornamented by about 35 longitudinal hairlike plications, which are crossed by somewhat finer transverse striations, dividing the surface into squares or rectangles. Between the transverse striations are numerous finer, closely crowded, delicate transverse lines.

Diameter of fragment described, 2.6 mm.

Occurrence.—ROCHESTER FORMATION. East of Tonoloway, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

INCERTAE SAEDIS

Genus SCOLITHUS Hall

SCOLITHUS VERTICALIS Hall

Plate XI, Fig. 8

Fucoides verticalis Hall, 1843, Geol. New York, Rep. 4th Dist.
Scolithus verticalis Hall, 1852, Pal. New York, vol. ii, p. 6, pl. ii, fig. 3.
Scolithus verticalis Nicholson and Hinde, 1874, Canadian Jour., n. s., vol. xiv, p. 138.
Scolithus verticalis Nicholson, 1875, Rep. Pal. Prov. Ontario, pt. ii, p. 40, fig. 16.
Scolithus clintonensis James, 1892, Bull. Geol. Soc. Amer., vol. iii, p. 33, footnote p. 35, fig. 5.
Scolithus verticalis Bassler, 1909, Bull. 2a, Virginia Geol. Survey, pl. viii, fig. 3.

Description.—Straight tubular borings at right angles to the bedding are seen at a few places in the Tuscarora sandstone which may be compared with similar borings in the upper beds of the Medina of New York, which were named *Scolithus verticalis* by Hall. They reach a length of several inches. They lack features rendering confident specific identification possible.

Diameter of tubes, about 3 mm.

Occurrence.—TUSCARORA FORMATION. Two miles northwest of Flintstone.

Collection.—Maryland Geological Survey.

SCOLITHUS KEEFERI Prouty n. sp.

Description.—Short, cylindrical tubes, penetrating the sandstone at right angles to the bedding. These borings occur in large numbers in the Keefer sandstone member of the Rochester formation in Washington County. They resemble *Scolithus linearis* and *S. verticalis,* but are shorter in most cases. They are made a new species because of the great difference between the geological horizon of these beds and those containing the forms previously described, rather than because of distinctive features.

Occurrence.—ROCHESTER FORMATION. In the Keefer sandstone member throughout the North Mountains.

Collections.—Maryland Geological Survey, U. S. Geological Survey.

Genus ARTHROPHYCUS Hall

ARTHROPHYCUS ALLEGHANIENSIS (Harlan)[1]

Plate XII, Figs. 1, 2

Fucoides alleghaniensis Harlan, 1831, Jour. Acad. Nat. Sci., Phila., vol. vi, p. 289, pl. xv.

Fucoides alleghaniensis Harlan, 1835, Medical and Physical Researches, p. 393, fig. 1.

Fucoides brongniartii Harlan, 1835, *Ibid.*, p. 398, fig. 2.

Fucoides harlani Conrad, 1838, 2d Ann. Rept. N. Y. Geol. Survey, p. 113.

Arthrophycus harlani Hall, 1852, Pal. N. Y., vol. ii, p. 5, pl. i, fig. 1; pl. ii, figs. 1a-c.

Arthrophycus alleghaniensis Sarle, 1906, Proc. Rochester Acad. Sci., vol. iv, p. 203.

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[1] For extended synonymy see Bassler, U. S. Nat. Mus., Bull. No. 92, vol. i, 1915, p. 70.

Description.—Subcylindrical flexuose stems, which do not taper; simple or branching; branches often digitate or fastigiate. Stems marked transversely by ridges as if articulated, often bearing a median depressed line.

This species occurs in two well-marked forms which were originally made distinct species by Harlan. The more common type in Maryland is that illustrated in Fig. 1. It consists of simple or little branched stems of uniform diameter which interlace to form intricate networks upon the under surface of sandstone slabs. This form was named *F. brongniartii* by Harlan. The second type branches repeatedly, the branches being strikingly digitate or fastigiate, as shown in Fig. 2. This form was named by Harlan *F. alleghaniensis.*

These problematical markings were originally supposed to be seaweeds, being termed *Fucus* by Harlan and later *Arthrophycus* ("jointed seaweed") by Hall. They were later supposed to be trails produced by Arthropoda. Sarle has shown that they may be borings of some organism, possibly one of the Vermes.

This is one of the most characteristic fossils of the Tuscarora sandstone, being widely distributed at this horizon throughout the Appalachian area.

Diameter of branches, 5 mm. to 15 mm.; occasionally larger.

Occurrence.—TUSCARORA FORMATION. In the upper beds throughout the area.

Collection.—Maryland Geological Survey.

MOLLUSCOIDEA

CLASS BRYOZOA

Order CTENOSTOMATA

Family RHOPALONARIIDAE

Genus RHOPALONARIA Ulrich

RHOPALONARIA TENERRIMA n. sp.

Plate XIII, Fig. 4

Description.—Zoarium adnate, half imbedded in its host, a brachiopod shell or tribolite carapace, and represented usually by clay-filled or empty excavations which show the original organism to have consisted of slightly fusiform internodes or cells connected by very delicate stolons, all arranged pinnately.

Comparisons of this species with other unusually delicate forms of *Rhopalonaria,* notably *R. attenutata* Ulrich and Bassler from the Clinton group and *R. tenuis* Ulrich and Bassler from the Middle Devonian show that in each case the present species is still more delicate, the width of the fusiform internodes especially being less than in any others. As these excavations undoubtedly represent only the basal creeping part of the zoarium it is probable that more differences would be revealed were the zooecia proper known.

Occurrence.—McKENZIE FORMATION. Lower part. Pinto, Maryland.

Collection.—U. S. National Museum.

Order CYCLOSTOMATA

Family FISTULIPORIDAE

Genus FISTULIPORELLA Simpson

FISTULIPORELLA TENUILAMELLATA n. sp.

Plate XIII, Figs. 10-14

Description.—Zoarium of very thin undulating lamellæ, 1 mm. or less in thickness and 20 to 30 mm. in diameter. Upper, celluliferous surface smooth; lower uncelluliferous side covered by a concentrically wrinkled epitheca. Maculæ distinct although quite small, granocellular and on a plane with the general surface. Zooecial apertures small, ovate in the vicinity of the maculæ but subcircular or subtrilobate in the intermacular spaces. Interzooecial spaces as usual in the genus, finely granulose, equal in width to that of the zooecium. A thin peristome surrounds the zooecium and passes posteriorly into the lunarium which is slightly thicker and more elevated. Measuring lengthwise 6 to 7 zooecia occur in 2 mm.

The unusually delicate lamella forming the zoarium in this species and the small zooecia, interzooecial spaces and maculæ form a combination of characters which will readily distinguish it from others of the genus.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 285 feet below top at Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Order TREPOSTOMATA

Family HETEROTRYPIDAE

Genus CYPHOTRYPA Ulrich and Bassler

CYPHOTRYPA EXPANDA n. sp.

Plate XIII, Figs. 5-9

Description.—Zoarium an explanate layer several millimeters thick and 3 to 4 cm. in diameter with the celluliferous upper surface smooth and the noncelluliferous basal surface lined with a concentrically wrinkled epitheca. Maculæ or areas of larger zooecia occur at regular intervals on a plane with the general surface. Zooecia thin-walled, polygonal 6½ to 7½ of the intermacular ones in 2 mm., the macular zooecia having a diameter half again as large. Acanthopores seldom distinguishable at the surface but occasionally seen in thin sections. True mesopores wanting.

Tangential thin sections show the thin-walled zooecia with mesopores absent, the sparse development of acanthopores and especially the clear intermural spaces characteristic of the Heterotrypidæ and allied families. In vertical sections the short immature region is followed by the mature zone where the walls thicken slightly, the acanthopores are developed and diaphragms occur at intervals ranging from one-third to one time their own diameter.

This new species although closely allied to the Helderbergian *C. corrugata* Weller from the Keyser limestone of West Virginia and Maryland, differs conspicuously in the thin lamellar zoarium instead of large hemispherical masses.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 285 feet below top at Keyser, West Virginia.

Collection.—U. S. National Museum.

Genus LEPTOTRYPA Ulrich

LEPTOTRYPA SILURICA n. sp.

Plate XIV, Fig. 7

Description.—This name is applied to delicate incrustations upon brachiopod shells and other organisms which are undoubtedly related to certain genera of the Heterotrypidæ but whose internal structure is uncertain because the zoaria so far noted are too thin for suitable sections. Acanthopores are present at the junction angles of the zooecia and this feature in connection with the thin-walled polygonal zooecia and absence of mesopores causes us to refer this species to *Leptotrypa.*

The delicate incrusting zoarium, thin-walled polygonal zooecia and their minute size (10 in 2 mm.) will distinguish the present species from all the associated forms.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 285 feet below top at Keyser, West Virginia.

Collection.—U. S. National Museum.

Family BATOSTOMELLIDAE

Genus ERIDOTRYPA Ulrich

ERIDOTRYPA sp.

Description.—Fragments of a narrow ramose bryozoan which in thin sections show relationship to *Eridotrypa* occur in the lower part of the McKenzie formation. On account of the rarity of bryozoa in these rocks these specimens are deemed worthy of mention although the material so far collected is not sufficient for the recognition of the species.

Occurrence.—MCKENZIE FORMATION. Lower part, 31 feet below top. Grasshopper Run.

Collection.—U. S. National Museum.

Genus LIOCLEMA Ulrich

LIOCLEMA TENUIRAMA n. sp.

Plate XIV, Figs. 8-12

Description.—Zoarium of slender, ramose, cylindrical smooth branches, one and one-half to two mm. in diameter. Zooecia thin-walled, polygonal, elongate, 8 in 2 mm. measuring lengthwise, sometimes in contact but usually separated by a row of mesopores. Acanthopores of medium size and number.

In thin sections the zooecial tubes are thin-walled and distinctly crenulated in the axial region becoming thickened in the peripheral zone where both mesopores and acanthopores are developed. Diaphragms absent in both zooecia and mesopores.

Although closely related to *Lioclema ramulosa* Bassler of the Rochester (Clinton shale) and probably a descendant of it, the present species is distinguished by its smaller acanthopores, fewer mesopores and more decided crenulation of the zooecial tubes in the immature region.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 285 feet below top at Keyser, West Virginia.

Collection.—U. S. National Museum.

Family AMPLEXOPORIDAE

Genus RHOMBOTRYPA Ulrich and Bassler

RHOMBOTRYPA RAMULOSA n. sp.

Plate XIV, Figs. 1-6

Description.—Zoarium small, of slender cylindrical branches 1½ to 2 mm. in diameter dividing at intervals of 3 to 4 mm. Surface smooth with maculæ of large zooecia scarcely evident. Zooecia small for the genus and with comparatively thick walls, polygonal in outline, frequently showing the characteristic arrangement in quincunx lines. Mesopores absent. About eight zooecia in 2 mm. measuring longitudinally and 12 in the same distance transversely. Thin sections as indicated on Plate XIV show the characteristic structure of Rhombotrypa save that this species reveals better developed acanthopores than any other of the genus. Although resembling *Rhombotrypa spinulifera* Bassler of the Clinton-Rochester shale this interesting new species differs in its more frequently dividing zoarium, entire absence of mesopores, smaller zooecia with thicker walls, and more numerous acanthopores. The arrangement of the zooecia, especially the internal structure, is identical in the two species.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 285 feet below top at Keyser, West Virginia.

Collection.—U. S. National Museum.

Order CRYPTOSTOMATA

Family RHABDOMESONTIDAE

Genus ORTHOPORA Hall

ORTHOPORA TONOLOWAYENSIS n. sp.

Plate XIV, Figs. 13-16

Description.—This rodlike bryozoan, the most abundant species in the Tonoloway limestone, is closely related to *Orthopora rhombifera* Hall and *O. regularis* Hall of the Helderbergian but differs from both in the greater development of interapertural spines or acanthopores. In longitudinal thin sections both the inferior and superior hemisepta are noted to be unusually well developed.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 285 feet below top at Keyser, West Virginia.

Collection.—U. S. National Museum.

Family PHYLLOPORINIDAE

Genus PHYLLOPORINA Ulrich

PHYLLOPORINA ASPERATOSTRIATA Hall

Plate XIII, Figs. 1-3

Retepora asperato-striata Hall, 1852, Nat. Hist. New York, vol. xi, p. 161, pl. xlC, figs. 2a-h.

Subretepora asperato-striata Miller, 1889, North American Geol. and Pal., p. 326.

Phylloporina asperato-striata Ulrich, 1890, Geol. Survey Illinois, vol. viii, p. 332, pl. 53, figs. 5-5b.

Phylloporina asperato-striata Grabau, 1901, Bull. New York State Mus., no. 45, p. 168, fig. 68.

Description.—Zoarium of rather regularly inosculating branches arising from a slightly expanded base and forming a reticulate, flat, undulating or broadly funnel-shaped expansion, sometimes reaching a diameter of 70 or 80 mm. Branches varying from 0.8 to 1 mm. in width, but usually the different parts of the same specimen are uniform in this respect. Fenestrules rather regular in shape, oval to subelliptical, but somewhat variable in size, the average being about 1.10 mm. in length and 0.45 mm. in width. Measuring longitudinally 9 to 10 fenestrules may be counted in 20 mm., while transversely 15 occupy the same space. The celluliferous side exhibits four to six ranges of zooecia. Apertures circular or subpolygonal, closely crowded together, 6 to 7 in 2 mm. In well-preserved examples the longitudinal striæ of the reverse side are seen under a magnifier to be minutely denticulate, thus suggesting the specific name.

Occurrence.—ROCHESTER SHALE. Western New York and Ontario, and the same horizon in southeastern Indiana. UPPER CLINTON, 14 feet below Keefer Sandstone, Flintstone, Maryland.

Collection.—U. S. National Museum.

Family FENESTELLIDAE

Genus FENESTELLA Lonsdale

FENESTELLA sp.

Description.—Fragments of a Fenestella undeterminable specifically, occur at this zone and on account of the rarity of such bryozoa in the Silurian rocks of Maryland are herewith mentioned.

Occurrence.—Milliken No. 2, Hancock No. 1.

Collection.—U. S. National Museum.

Family ARTHROSTYLIDAE

Genus HELOPORA Hall

HELOPORA sp.

Description.—Specimens of two species of *Helopora* either closely allied or specifically identical with *H. bellula* Billings and *H. lineopora* Billings from the Gun River and Jupiter River formation of the Island of Anticosti, occur in considerable abundance in the Lower Clinton sandstones just above the Frankstown ore in Pennsylvania but their preservation is not good enough to make their identification certain. Attention is called to these specimens in the hope that future collectors will secure better material for study.

Occurrence.—CLINTON. Six to ten feet above the Frankstown ore, ½ mile northwest of Frankstown, Pennsylvania.

Collection.—U. S. National Museum.

CLASS BRACHIOPODA

Order ATREMATA

Superfamily LINGULACEA

Family LINGULIDAE

Genus LINGULA Bruguière

LINGULA CLARKI Prouty n. sp.

Plate XV, Figs. 1, 2

Description.—Shell elongate-oval, subacute at beak, obtusely rounded at front, nearly the same width throughout the greater part of its length, having in consequence its side margin but slightly rounded. Surface marked by concentric lines or folds and by two diverging lines beginning at the beak and extending forward in some cases for two-thirds the length of the shell. In some specimens the shell descends more rapidly toward the lateral margins from these lines. This character is not constant, however. There is a suggestion in some of the forms of longitudinal radiating striæ. Shell becomes nearly flat at front margin, but is distinctly elevated toward the beak. Maximum elevation of shell about one-third way from beak toward front.

This species resembles closely *L. oblonga* of the New York Clinton. It differs, however, in having a more acute beak and a less truncated front margin. It also resembles, but to a less marked degree, *L. lamellata* of the New York Rochester. In the four specimens observed from Maryland, there seems to be a constancy in general outline. Not an abundant fossil.

Length, 14 mm.; width, 8 mm.

Occurrence.—MCKENZIE FORMATION. Cedar Cliff, 48 feet below the top of the formation.

Collection.—Maryland Geological Survey.

LINGULA SUBTRUNCATA Prouty n. sp.

Plate XV, Figs. 3, 4

Description.—Shell elongate-oval, semi-obtuse at beak, subtruncately rounded at front, nearly the same width throughout length, thus having the lateral margins but slightly curved, greatest width a little toward the beak from the center of the shell; nearly flat anteriorly, but considerably convex toward the beak. Surface of the shell marked with rather faint concentric lines which are crossed by numerous fine, rather indistinct, radiating striæ. There is a very shallow depression extending from beak to near front.

This form, of which there is but one whole valve and another fragment, closely resembles *Lingula clarki,* but seems to differ in having a slightly more obtuse beak, a slightly more truncate anterior margin and less well marked diverging lines on the surface.

This species is even more nearly allied to *Lingula oblonga* than is *Lingula clarki,* on account of its more truncate anterior border.

It is possible that a larger number of specimens of this form will show the species to be *Lingula clarki.* Only two specimens, which occur about 100 feet below the top of the McKenzie, were seen.

Length, 15 mm.; width, 9 mm.

Occurrence.—MCKENZIE FORMATION. Cedar Cliff, Flintstone.

Collection.—Maryland Geological Survey.

LINGULA (?) n. sp.

Description.—Almost regularly elongate-oval, much longer than wide; front rounded; beak bluntly acuminate; surface marked by undulating, concentric striæ. Most of the individuals have a marked longitudinal groove extending along center of shell. This groove is narrower and deeper toward the beak.

This supposed new species is very closely allied to the English form *L. longissima.* The latter has, however, a more nearly elliptical outline than the Maryland form. It also closely simulates *L. subelliptica* and *L. clintoni* from the New York Clinton.

Length, 14 mm.; width, 8 mm.

Occurrence.—McKENZIE FORMATION. Pinto, 124 feet below the top of the formation.

Collection.—Maryland Geological Survey.

LINGULA sp.

Plate XV, Figs. 5-7

Description.—Fragments of two or perhaps three species of *Lingula,* all of which are too imperfect to permit specific identification, occur in the Bloomsburg member of the Wills Creek formation.

Occurrence.—WILLS CREEK FORMATION. Round Top.

Collection.—Maryland Geological Survey.

Order NEOTREMATA

Superfamily DISCINACEA

Family DISCINIDAE

Genus ORBICULOIDEA d'Orbigny

ORBICULOIDEA CLARKI Prouty n. sp.

Plate XV, Figs. 8-10

Description.—Nearly orbicular, sometimes slightly oval with more angular portion directed posteriorly, brachial valve a mediumly low eccentric cone, apex from one-third to one-fourth the diameter of shell from posterior margin, surface marked by fine, more or less close set, interrupted, concentric ridges, more numerous and less prominent anteriorly than posteriorly where several lines coalesce as they sweep around the apex; pedicle valve less convex and with apex less eccentric than in dorsal valve; groove of uniform width and passing from region of apex to the posterior margin; surface of pedicle valve more regularly marked than brachial, due to less eccentricity of apex.

This species closely resembles *Orbiculoidea rugata* of the British Upper Ludlow, from which species it differs chiefly in the character of its groove.

Diameter, 10 mm. to 20 mm.

Occurrence.—McKENZIE FORMATION. Cedar Cliff, Six-mile House. ROCHESTER FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

ORBICULOIDEA sp.

Plate XV, Fig. 11

Description.—A fragment of an Orbiculoidea, which is too imperfect to permit specific identification, occurs in the upper part of the Tonoloway formation. It may be compared with *O. schucherti* of the Keyser limestone.

Diameter, 15 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto.

Collection.—Maryland Geological Survey.

Superfamily CRANIACEA

Family CRANIIDAE

Genus PHOLIDOPS Hall

PHOLIDOPS SQUAMIFORMIS Hall

Plate XV, Figs. 12-14

Orbicula ? squamiformis Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 108, fig. 1.
Orbicula ? squamiformis Hall, 1852, Pal. N. Y., ii, 1852, p. 250, pl. liii, fig. 4.
Craniops squamiformis Hall, 1859, 12th Rept. N. Y. State Cab. Nat. Hist., p. 84.
Pholidops squamiformis Hall, 1859, Pal. N. Y., vol. iii, p. 490, pl. ciiiB, fig. 6.
Pholidops squamiformis Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. 1, p. 156; pl. xli, fig. 21.
Pholidops squamiformis Grabau, 1901, Bull. N. Y. State Mus., vol. xlv, p. 179, fig. 82.
Pholidops squamiformis Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 179, fig. 82.

Description.—Oval, depressed, eccentric; surface marked by strong concentric lamellæ which are close together on the posterior but further apart on the anterior portion; shell thin, calcareous.

This species is very closely related to, if not identical with, *P. implicata* of the Wenlock limestone, England.

Length, 3.8 mm.; width, 3 mm.

Occurrence.—ROCHESTER FORMATION. Abundant throughout the Maryland area.

Collection.—Maryland Geological Survey.

Order PROTREMATA

Superfamily ORTHACEA

Family ORTHIDAE

Subfamily DALMANELLINAE

Genus DALMANELLA Hall and Clarke

DALMANELLA ELEGANTULA (Dalman)

Plate XV, Figs. 15-18

Orthis elegantula Dalman, 1828, Kongl. Svenska Vet.-Akad. Handl., 1827, p. 117, pl. ii, fig. 6.

Orthis canalis Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 105, fig. 6.

Orthis elegantula Hall, 1852, Pal. N. Y., vol. ii, p. 252, pl. lii, fig. 3.

Orthis elegantula ? var. Hall, 1852, Pal. N. Y., vol. ii, p. 57, pl. xx, fig. 7.

Orthis elegantula Billings, 1856, Can. Nat. Geol., vol. i, p. 136, pl. ii, fig. 5.

Orthis elegantula Billings, 1863, Geol. Can., p. 312, fig. 320.

Orthis elegantula Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., p. 150, pl. xxi, figs. 11-17.

Orthis elegantula Nettelroth, 1889, Kentucky Fossil Shells, Mem. Ky. Geol. Survey, p. 37, pl. xxxii, figs. 52-57.

Orthis elegantula Beecher and Clarke, 1889, Mem. N. Y. State Mus., vol. i, p. 14, pl. i, figs. 3-12.

Dalmanella elegantula Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. i, pp. 207, 224, pl. vc, figs. 15-19.

Orthis (*Dalmanella*) elegantula Foerste, 1895, Geol. Ohio, vol. vii, p. 581, pl. xxv, figs. 11, 17.

Dalmanella elegantula Kindle, 1903, Ind. Dept. Geol. and Nat. Res., 28th Ann. Rept., p. 433, pl. ii, fig. 9.

Description.—" Shell semi-oval, ventral valve nearly or quite flat, sometimes with a depression along the center; dorsal valve very convex, extremely elevated toward the beak, which is much extended and curved over the area; hinge-line shorter than the width of the shell; area narrow, not extended to the extremities of the hinge-line; surface covered with fine striæ, which are dichotomous toward the margin and arched toward the hinge-line. In the most perfect specimens the diverging striæ are crossed by extremely fine, concentric striæ."—Hall, 1852.

This species in Maryland is as a rule larger and a trifle wider in front than the forms figured from New York, being more like the forms figured from Waldron, Indiana, and from the Anticosti group in Eastern Canada.

Length of pedicle valve, 13 mm.; width, 12 mm. A second specimen is 4 mm. long, 3.8 mm. wide.

Occurrence.—McKenzie Formation. Pinto, Cedar Cliff, Six-mile House, Flintstone, Maryland; Grasshopper Run, West Virginia; abundant throughout the Maryland area. Rose Hill Formation. Pinto, Cresaptown, Cumberland, Six-mile House, Flintstone, Maryland; Great Cacapon, Sir Johns Run, Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Family RHIPIDOMELLIDAE

Subfamily RHIPIDOMELLINAE

Genus RHIPIDOMELLA Œhlert

Rhipidomella hybrida (Sowerby)

Plate XV, Figs. 19-22

Orthis hybrida Sowerby, 1839, Murchison's Silurian System, p. 630, pl. xiii, fig. 11.

Orthis hybrida Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 105, fig. 7.

Orthis hybrida Hall, 1852, Pal. N. Y., vol. ii, p. 253, pl. lii, fig. 4.

Orthis hybrida Roemer, 1860, Die Silurische Fauna des West. Tennessee, p. 63, pl. v, fig. 6.

Orthis hybrida Meek and Worthen, 1868, Geol. Survey Ill., p. 371, pl. vii, fig. 7.

Orthis hybrida Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., p. 149, pl. xxi, figs. 18-25.

Orthis hybrida Hall, 1883, 2d Ann. Rept. N. Y. State Geol., pl. xxxvi, figs. 1-5.

Orthis hybrida Foerste, 1885, Bull. Denison Univ., vol. i, p. 83, pl. xiii, fig. 10.

Orthis hybrida Beecher and Clarke, 1889, Mem. N. Y. State Mus., vol. i, p. 17, pl. i, figs. 13-18.

Orthis hybrida Nettelroth, 1889, Kentucky Fossil Shells, Mem. Ky. Geol. Survey, p. 39, pl. xxxi, figs. 32-35.

Orthis hybrida ? Hall, 1863, Trans. Albany Inst., vol. iv, p. 209.

Rhipidomella hybrida Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. 1, pp. 210, 224, pl. vi, figs. 1-5.

Orthis (*Rhipidomella*) hybrida Foerste, 1895, Geol. Ohio, vol. vii, p. 584, pl. xxv, fig. 10.

Rhipidomella hybrida Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 188, fig. 98.

Description.—"Lenticular, most convex near the beaks, wider than long, radiated; radii increasing in number toward the margin; front rather straight, valves equal; hinge-line short. Length, 5½ lines; width, 6 lines."—Sowerby, 1839.

Ventral valves depressed from the center to the base; dorsal valve regularly convex, sometimes slightly depressed in center near the beak; radiating striæ sharp and dichotomous, arching upward on the sides and hinge margin; radiating striæ crossed by very fine concentric striæ. The species is distinguished by the similar appearance of the dorsal and ventral valves, one of which has a broad, undefined depression along the center.

Length of small pedicle valve, 9 mm.; width, 9.5 mm. Length of large pedicle valve, 15 mm.; width, 17 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Sixmile House, Flintstone, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

Superfamily STROPHOMENACEA

Family STROPHOMENIDAE

Subfamily RAFINESQUININAE

Genus LEPTAENA Dalman

LEPTAENA RHOMBOIDALIS (Wilckens) [1]

Plate XV, Figs. 23, 24

Conchita rhomboidalis Wilckens, 1769, Nachrict von selten Versteinerungen, p. 77, pl. viii, figs. 43, 44.

Strophomena undulosa Conrad, 1841, 5th Ann. Rept. Geol. Survey N. Y., p. 54.

Strophomena depressa Vanuxem, 1842, Geol. N. Y., Rept. 3d Dist., p. 79, fig. 5.

Strophomena depressa Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 77, fig. 5; p. 104, fig. 2.

Leptaena rhomboidalis Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. 1, p. 279, pl. viii, figs. 17-31; pl. XVA, figs. 40-42; pl. xx, figs. 21-24.

Description.—" Shell semioval or semicircular; hinge-line equal to or extending beyond the width of the shell; dorsal valve having the upper part nearly flat, slightly convex or even concave, with strong concentric undulations, toward the margin abruptly inflated; ventral valve parallel to the dorsal valve, presenting a deep concavity. Surface marked by prominent radiating striæ.

[1] For a more extended synonymy of this species see Bassler, Bull. U. S. Nat. Museum, No. 92, 1915, vol. i, p. 710.

"The cardinal area is narrow, and extended to the extremities of the hinge-line; the foramen is broad and spreading, but filled by a callosity of the ventral valve, which has a narrow groove at its summit for the protrusion of the pedicle; the apex of the dorsal valve is often, and perhaps always, perforated.

"The flatter portions of both valves are strongly marked by concentric undulations, which are crossed by fine striæ. On the deflected portions there are no undulations, the striæ alone marking the surface. Sometimes the shell is nearly flat, the deflected portion being either very narrow or not at all conspicuous. The undulations are variable in number, even in shells of the same size, and are not to be relied upon as characteristic. In very old shells they are not so strong as in young ones, or those of medium size. The striæ crossing the undulations are likewise variously prominent in different individuals, frequently bifurcating, and in well preserved surfaces crossed by fine concentric striæ. The interior is always peculiar and sufficiently characteristic, though the exterior characters are very closely simulated by a different shell in the shaly limestone of the Helderberg.

"Fossil has a very wide range, extending from the Clinton to the Onondaga formations. Specimens from the lower rocks are always smaller, the undulations fewer, and the valves less inflated than those of the middle or upper Silurian. Internal structure not often seen."—Hall, 1852.

Hall says further that the above fossil is much smaller and less abundant in the Clinton, but is abundant and well defined in the Niagara.

One specimen is 13 mm. long, 19 mm. wide; a second is 15 mm. long, 27 mm. wide.

Occurrence.—McKENZIE FORMATION. Grasshopper Run, West Virginia. ROCHESTER FORMATION. Throughout the Maryland area. Especially abundant in the green shales and the two bluish-gray limestone bands which immediately overlie the Keefer sandstone. ROSE HILL FORMATION. Flintstone, in uppermost beds of the formation.

Collection.—Maryland Geological Survey.

Genus STROPHEODONTA Hall

STROPHEODONTA CORRUGATA (Conrad)

Plate XVI, Figs. 4-9

Stropheodonta corrugata Conrad, 1842, Jour. Acad. Nat. Sci., Phila., vol. viii, p. 256, pl. xiv, fig. 8.

Strophomena corrugata Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 73, fig. 2 on p. 72.

Leptaena corrugata Hall, 1852, Pal. N. Y., vol. ii, p. 59, pl. xxi, figs. 2a-2c.

Strophomena corrugata Hall, 1859, 12th Rept. N. Y. State Cab. Nat. Hist., p. 82.

Stropheodonta corrugata Hall, 1883, 2d Ann. Rept. N. Y. State Geol., pl. xlvi, fig. 1.

Strophomena corrugata Foerste, 1890, Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 303, pl. vi, fig. 25.

Stropheodonta corrugata Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. 1, pl. xv, fig. 1, pt. 2 (1895), pl. lxxxiv, fig. 14.

Stropheodonta corrugata Grabau, 1901, Bull. Buffalo Nat. Sci., vol. vii, p. 181, fig. 85.

Stropheodonta cf. *corrugata* Kindle and Breger, 1904, 20th Ann. Rept. Dept. Geol. Nat. Res. Indiana, p. 429, pl. i, fig. 3.

Stropheodonta corrugata Grabau and Shimer, 1907, N. Amer. Index Fossils, vol. i, p. 213, fig. 253.

Description.—"Semioval, nearly flat; hinge-line extending into small acute ears; surface marked by fine, prominent striæ, which alternate with finer ones, striæ usually unequal, but often equal in size and regularly bifurcating, crossed by fine concentric lines; the hinge margin marked by oblique folds, which are sometimes obsolete; cast striated; except on each side of the beak and below, where it is punctate.

"This is a very beautiful species, found more commonly in the upper green shale at Rochester than elsewhere. The striæ are usually unequal in size, increasing not by regular bifurcation, but by the appearance of a small one between the larger, which, if followed, becomes in turn large, while a smaller one takes rise between it and the next; in some instances, the increase is by regular bifurcation. The fine concentric striæ are often obsolete. The shell is usually marked by several oblique plications along the hinge-line on each side of the beak, but these marks are not always visible in compressed specimens. In these oblique folds the shell resembles a species of the Trenton limestone (*L. subtenta*), but it is entirely distinct. The interior of the dorsal valve is striated nearly to the beak, and the striæ appear to be regularly bifurcating."—Hall, 1852.

This form is a characteristic horizon-marker because of its wide lateral and small vertical range. It is replaced toward the top of the Rochester by forms which resemble it closely but are slightly more gibbous, have less acute extremities and are generally shorter. (See *S. corrugata* var. *pleuristriata* Foerste.)

Average size: Length, 20 mm.; width, 25 mm.

Occurrence.—MCKENZIE FORMATION. Six-mile House. ROCHESTER FORMATION. Abundant in all sections, especially near Cumberland and Six-mile House. ROSE HILL FORMATION. Cresaptown, Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

STROPHEODONTA CORRUGATA var. PLEURISTRIATA (Foerste)

Plate XVI, Figs. 10-12

Leptaena corrugata Hall, 1852 (part), Pal. N. Y., vol. ii, p. 59, pl. xxi, figs. 2d, 2e.

Strophomena corrugata var. *pleuristriata* Foerste, 1890, Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 303, pl. vi, figs. 26, 27.

Description.—"Shell broader than long; the cardinal margin equal in width to the shell or slightly produced, forming small acute ears; the sides subparallel posteriorly, anteriorly rounded into the semicircular anterior margin of the shell; occasionally with faint, almost obsolete folds along the cardinal margin, corresponding in direction to the lateral margins of the acute ears when present.

"Dorsal valve flat in some specimens forming almost a plane surface. In one specimen, a cast, there are depressions corresponding to two short cardinal teeth forming an angle with one another of about 120° and a third depression between about twice as long as the teeth, corresponding to a mesial ridge.

"Ventral valve flattened, moderately convex, greatest convexity near the beak, thence sloping gradually toward the front and sides and more rapidly toward the postero-lateral margin. In casts of this valve two depressions are found forming an angle of about 80° with one another.

These correspond to the cardinal teeth of the ventral valve, outlining the posterior side of the muscular depression. The surface of both valves is covered with fine radiating striæ, about eight or nine within a width of 2 mm.; at more or less regular intervals, varying usually from four to six or seven, certain of the striæ are slightly broader and decidedly more elevated and prominent. Concentric striæ, when present, are always less prominent than radiating striæ and are closely set; some disposed at irregular intervals, and more prominent, form striæ of growth."—Foerste, 1890.

The Maryland forms seem identical with the above description of Foerste. The smaller specimens studied are identical in size with those figured from Tennessee, while the largest individuals are a trifle larger than the ones figured from New York. This species is found in the upper beds of the Rochester formation.

Length, 20 mm.; width, 29 mm.

Occurrence.—McKENZIE FORMATION. Rose Hill. ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House. ROSE HILL FORMATION. Cresaptown.

Collection.—Maryland Geological Survey.

STROPHEODONTA CONVEXA Prouty n. sp.

Plate XVII, Figs. 1-5

Description.—Shell semielliptical, about three-quarters as long as broad; ventral valves very convex, almost uniformly arched from beak to front. Entire valve markedly ventricose, except where the valve becomes flattened toward the cardinal extremities; area narrow, usually not over .5 mm. in width; hinge-line denticulate, less than one-half its length; surface marked by fine radiating striæ six to seven to the mm., some of which are considerably larger than the rest, there being from three to six smaller ones between them. The radiating striæ are crossed by rather indistinct, concentric wrinkles at intervals over the entire surface and by fine, concentric striæ which are best seen on a partially exfoliated shell and which gives a rugose character to the ornamentation.

Many features of this shell are identical with the figured form of *Strophomena hecuba* Billings of the Lorraine at Anticosti, but it is somewhat smaller and does not possess the linguiform projection of the latter species. It is abundant in the shale and limestone below the Keefer sandstone.

Length, 28 mm.; width, 39 mm.

Occurrence.—ROCHESTER FORMATION. Flintstone, Maryland; Great Cacapon, West Virginia. ROSE HILL FORMATION. In the uppermost beds of the formation at Flintstone, Maryland, Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

STROPHEODONTA DEFLECTA Prouty n. sp.

Plate XVI, Figs. 1-3

Description.—Shell small, nearly semicircular in outline greatest width at the hinge-line; cardinal angles obtusely rounded; front margin very slightly arcuate; ventral valve markedly convex, maximum inflation about two-thirds transverse radial distance from beak to margin, from where shell rounds smoothly and slopes abruptly downward, this front marginal slope makes an angle of some 60° to 70° with the visceral disc, which is gently rounded, fullest at the center and sloping away more rapidly at the sides than toward the beak with surface becoming slightly concave toward the cardinal angles. Surface marked by fine radiating striæ crossed by fine concentric striæ; casts strongly punctate except in umbonal region. About 20 of the radiating striæ seem to be stronger than the rest.

This shell seems very closely allied to *S. julia* of the Anticosti group, but is uniformly smaller and more semicircular in its outline with a smaller angle between visceral disc and anterior slope. It also approaches *S. acuminata* of Maryland from which it is readily distinguished by its shorter and more obtuse cardinal extremity and smaller size.

Length, 11 mm.; breadth, 17 mm.; convexity of ventral valve, 3 mm. to 4 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Six mile House.

Collection.—Maryland Geological Survey.

STROPHEODONTA ACUMINATA Prouty n. sp.

Plate XVII, Figs. 6, 7

Description.—Nearly semicircular in outline, cardinal extremities extended and angular; hinge-line slightly convex; ventral valve convex, maximum inflation from one-half to two-thirds radial distance from beak whence the shell slopes rather abruptly downwards; visceral disc has maximum mid-anterior inflation, with broad low fold running posteriorly and narrowing toward beak; toward the cardinal disc becomes slightly hollowed; surface marked by fine radiating striæ which are crossed by fine concentric striæ, the latter very poorly preserved on casts. Casts, however, show strong punctation except on umbo; beak scarcely discernible from cardinal areas.

This form resembles both *S. deflecta* and *S. julia* Billings. It is distinguished from them by its acute cardinal extremity. It is found in the green shales immediately overlying the Keefer sandstône.

Length, 14 mm.; breadth, 28 mm.; convexity of central valve, 4 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

STROPHEODONTA VARISTRIATA (Conrad)

Plate XVIII, Figs. 1-3

Leptæna indenta ? Conrad, 1838, Ann. Rept. N. Y. Geol. Survey, Paleont., p. 117.

Strophomena varistriata Conrad, 1842, Jour. Acad. Sci., Phila., vol. iii, p. 255, pl. xiv, fig. 6.

Strophomena rectilateras Conrad, 1842, *Ibid.*

Strophomena impressa Conrad, 1842, *Ibid.*

Stropheodonta varistriata Hall, 1859, Pal. N. Y., vol. iii, p. 180, pl. viii, figs. 1-16; pl. xvi, figs. 1-8.

Stropheodonta varistriata Weller, 1903, Pal. N. J., N. J. Geol. Survey, vol. iii, p. 261, pl. xxiv, figs. 13, 14.

Stropheodonta varistriata Shimer, 1905, Bull. N. Y. State Mus., 80, p. 240.

Stropheodonta varistriata Grabau, 1906, Bull. N. Y. State Mus., 92, p. 115, fig. 23; pl. xxxvii, fig. 35.

Stropheodonta varistriata Grabau and Shimer, 1909, N. Amer. Index Fos., vol. i, p. 214, fig. 255.

Stropheodonta varistriata Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 69, pl. lix, figs. 1, 2.

Description.—"Shell semioval, varying in form from length and width equal to length greater or less than the width: hinge-line equal to or greater than the width of the shell below; extremities rounded or salient. Dorsal valve flat, or more or less concave according to the convexity of the ventral valve, but not conforming entirely to the curvature of the latter. Ventral valve varying from slightly convex to gibbous, and sometimes abruptly arching towards the front; umbonal region more or less prominent; beak usually a little elevated. Area narrow, almost linear. Foramen linear or none.

"Surface often finely and evenly marked with straight or slightly undulating striæ; more often with prominent sharp striæ at more or less equal distances from each other, and the intermediate spaces by minute equal striæ; and again in other specimens by alternating larger and smaller striæ, of which there are frequently three regular gradations in size. Radiating striæ crossed by fine concentric elevated lines, and often by undulations or indentations which are more conspicuous on those shells where the striæ are in fascicles of finer between stronger ones. Vascular impressions of the ventral valve circumscribed by lamellæ, more or less distinctly flabellate: impressions of adductor muscles elongate-oval."—Hall, 1859.

The specimens observed in the Tonoloway formation of Maryland have nearly equal striæ, in which respect they differ from the typical New York shells. This feature, however, is observed in some shells of this species in the latter state. In other respects they seem indistinguishable from *S. varistriata* Conrad, to which they are here referred. This is a rare species in the Tonoloway.

Length, 8 mm.; width, 10 mm.

Occurrence.—TONOLOWAY FORMATION. National Road, Martin Mountain.

Collection.—Maryland Geological Survey.

Subgenus LEPTOSTROPHIA Hall and Clarke

STROPHEODONTA (LEPTOSTROPHIA) BIPARTITA var. NEARPASSI Barrett

Plate XVIII, Fig. 4

Stropheodonta nearpassi Barrett, 1878, Amer. Jour. Sci., 3d ser., vol. xv, p. 372.

Stropheodonta bipartita Weller, 1903, N. J. Geol. Survey, Paleont., vol. iii, p. 226, pl. xx, figs. 1-5.

Stropheodonta (Leptostrophia) bipartita Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 316, pl. lxvii, figs. 17, 18.

Description.—" Shell with thin, nearly flat brachial valve and slightly convex pedicle valve, longitudinally subsemielliptical in outline, the hinge-line produced beyond the body of the shell into mucronate extensions, hinge-line crenulate.

" Surface of both valves marked by fine, irregularly alternating, angular, raised striæ, which are not continuous over the umbo to the beak, and which curve outward on the sides of the shell in passing to the margin, the curvature becoming stronger on approaching the hinge-line. The surface is also marked by much finer, crowded, concentric lines, which continue to the beak. Oblique wrinkles along the cardinal margin are present in many specimens. The interior of the valves, more especially the pedicle, is covered with fine, closely crowded papillæ, which gives to the surface of internal casts a finely pitted or punctate appearance. These internal papillæ may frequently be detected through the thin shell substance as dark spots, giving it a punctate appearance, but there are apparently no perforations. The muscular impressions of the pedicle valve are rather large and divergent and are free from impressions of papillæ. In the interior of the brachial valve a low median ridge reaches more than half-way to the front of the shell.

" The dimensions of a medium-sized specimen are: Length, 28 mm.; breadth, 30 mm."—Weller, 1903.

" This species is the same as *Stropheodonta bipartita* which Weller describes from the Decker Ferry of New Jersey and which he considers the same as the three shells described by Hall in Volume II of the Paleontology of New York under the names *Leptæna* sp., *Leptæna bipartita,* and *Stropheodonta textilis,* all from the Coralline limestone of Schoharie, New York. It differs from the three forms described by Hall in having the striæ curve outwards on the sides of the shell in approaching the margins, the curvature increasing towards the posterior portion of the shell. This curvature is not mentioned in Hall's description, and on examining the type material the striæ do not curve but radiate from the beak straight."—Maynard, 1913.

These shells differ so constantly from Hall's form that the varietal name *nearpassi* is here proposed for them. They occur in the uppermost beds of the Tonoloway formation and are abundant in the *Chonetes jerseyensis* zone of the overlying Keyser limestone. They are also characteristic of the Decker Ferry of New Jersey.

Length, 22 mm.; width, 32 mm.

Occurrence.—TONOLOWAY FORMATION. Quarry, Standard Lime and Stone Co., Keyser, West Virginia.

Collection.—Maryland Geological Survey.

STROPHEODONTA sp.

Description.—Several imperfect shells of a large species of *Stropheodonta* have been found in the middle of the Tonoloway associated with a profusion of *Rhynchospira globosa, Schuchertella rugosa,* bryozoa, etc. They are larger than is usual in *S.* (*Leptostrophia*) *bipartita,* but do not permit specific identification.

Occurrence.—TONOLOWAY FORMATION. Quarry, Standard Lime and Stone Co., Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Subfamily ORTHOTETINAE

Genus SCHUCHERTELLA Girty

SCHUCHERTELLA SUBPLANA (Conrad)[1]

Plate XVIII, Figs. 5-7

Strophomena subplana Conrad, 1842, Jour. Acad. Nat. Sci., Phila., vol. viii, p. 258.

Strophomena subplana Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 104, fig. 1.

[1] For the extended synonymy of this species see Bassler, Bull. U. S. Nat. Mus., No. 92, 1915, vol. ii, p. 1151.

Strophomena subplana Hall, 1859, 12th Rept. N. Y. State Cab. Nat. Hist., p. 82.
Leptæna subplana Hall, 1852, Pal. N. Y., vol. ii, p. 259, pl. liii, figs. 8-10.
Orthothetes subplana Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. 1, p. 255, pl. ix, figs. 21-24; pl. ixA, fig. 19, pl. xiA, figs. 9-12.

Description.—"Semioval, with sharp radii alternating in size, larger and more distinct near the hinge-line; superior valve slightly concave, with a plane-convex umbo; hinge-line elevated above that of the opposite valve; area oblique: extremities of hinge-line slightly salient. Length, $1\frac{1}{8}$ in.; length of hinge-line, $1\frac{1}{2}$ in.; width of shell, $1\frac{3}{8}$ in."—Conrad, 1842.

Striæ often bifurcate before reaching the margin and are crossed by strong concentric striæ. The measurements given by Conrad are practically those of the mature forms as found in Maryland.

The shell has striæ a trifle finer than the typical *subplana* in the American Museum, but this character seems to be variable in type specimens.

Length, 29 mm.; width, 35 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

SCHUCHERTELLA TENUIS (Hall)

Plate XVIII, Figs. 8-11

Streptorhynchus tenuis Hall, 1863, Trans. Albany Inst., vol. iv, p. 210.
Streptorhynchus tenuis Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., p. 150, pl. xxiii, figs. 11-13.
Streptorhynchus tenuis Hall, 1882, 11th Rept. State Geol. Indiana, p. 287, pl. xxiii, figs. 11-13.
Streptorhynchus tenuis Foerste, 1887, Bull. Denison Univ., vol. ii, p. 105, pl. viii, figs. 21, 32, 38.
Streptorhynchus tenuis Nettelroth, 1889, Kentucky Fossil Shells, Mem. Ky. Geol. Survey, p. 142.
Streptorhynchus tenuis Lesley, 1890, Geol. Survey Penn., Rept. P4, p. 1098, figs.
Orthothetes tenuis Hall and Clarke, 1892, Pal. N. Y., vol. viii, pt. 1, p. 255.
Strophomena (Orthothetes) tenuis Foerste, 1895, Geol. Ohio, vol. vii, p. 568, pl. xxvii, figs. 21, 32, 38.

Description.—"Shell large, semicircular or broadly semielliptical, cardinal extremities rounded. Ventral valve slightly concave; area nar-

row; beak slightly elevated. Dorsal valve moderately convex, umbo not prominent, arcuate near the front margin, and compressed near the cardinal extremities. Surface marked by moderately fine, rounded, alternately large and small thread-like striæ, which are strongly curved on the lateral portion of the shell, crossed by very fine concentric striæ, giving, under a lens, a beautiful rugose character. Substance of shell very thin."
—Hall, 1879.

This specimen is distinguished by its large size, rounded cardinal extremities and rugose character of surface.

Measurements of two Maryland forms are as follows: Length, 32 mm.; breadth, 44 mm.; and length, 31 mm.; breadth, 43 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House, Flintstone. ROSE HILL FORMATION. Pinto.

Collection.—Maryland Geological Survey.

SCHUCHERTELLA ELEGANS Prouty n. sp.

Plate XVIII, Figs. 12-14

Description.—Shell subelliptical in outline, breadth greater than length; brachial valve slightly convex, sometimes with a very broad and very shallow sinus; pedicle valve more strongly convex, more elevated toward beak, which is rather strong and smoothly incurved to and a little in front of the cardinal line; hinge-line straight and considerably less than width of shell; surface of shell marked by many prominent angular radiating plications which are crossed by fine raised concentric striæ; plications increased by interplicational growths; many of the forms show a few more prominent growth lines.

This is a very beautiful little fossil, especially when viewed under a lens to bring out the fine, silky, concentric striæ. It is found about 30 feet above the Keefer sandstone.

Largest shell observed: Length, 11 mm.; breadth, 14 mm.

Occurrence.—ROCHESTER FORMATION. Pinto, Rose Hill, Cumberland, Six-mile House, East of Tonoloway.

Collection.—Maryland Geological Survey.

SCHUCHERTELLA INTERSTRIATA (Hall)

Plate XIX, Figs. 1-4

Orthis interstriata Hall, 1852, Pal. N. Y., vol. ii, p. 325, pl. lxxiv, figs. 1, 2.

Orthothetes hydraulicus Grabau, 1900, Bull. Geol. Soc. Amer., vol. ii, p. 365, pl. xxii, figs. 1a-c (non Whitfield).

Orthothetes hydraulicus Grabau, 1901, Bull. 45 N. Y. State Mus., p. 184, fig. 92.

Orthothetes hydraulicus Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 184, fig. 92.

Orthothetes interstriatus Weller, 1903, Geol. Survey N. J., Pal. vol. iii, p. 229, pl. xx, fig. 349.

Orthothetes interstriatus Schuchert, 1903, Amer. Geol., vol. xxxi, p. 165, fig. 277.

Schuchertella interstriata Grabau, 1910, Mich. Geol. Survey, Monroe Formation, p. 121, pl. xvii, figs. 4, 5; pl. xxxii, figs. 1a-c.

Description.—" The pedicle valve has a slightly elevated beak, with a low triangular cardinal area, which is flat and transversely striate; delthyrium moderate, covered in great part by a strong convex deltidium. The cardinal teeth are prominent and supported by two short and narrow dental plates, which have the same angle of divergence as the sides of the delthyrium. The cardinal extremities are obtuse, the hinge-line being shorter than the greatest width of the shell, while the front is uniformly rounded.

" The brachial valve has a very narrow hinge area which is erect, making a moderately obtuse angle with the hinge area of the pedicle valve. A strong band-like chilidium covers the median fissure. Between it and the deltidium there is a narrow open space through which can be seen the cardinal process, which appears bilobed; surface of both valves marked with strong, rounded, but sharply defined radiating striæ, which curve slightly upward on the lateral margins near the cardinal area. The strongest of these reach close upon the beak. Passing forward, new striæ appear between them, as soon as they have separated by more than their own width. Additional sets of stria appear as the shell increases in size, these having been observed up to the fifth generation. The striæ are cancellated by uniform, close, fine and regular concentric lines which are most prominent on the striæ."—Grabau, 1900.

This species differs from *S. hydraulica* chiefly in its subequal striæ and its prevailingly greater size. In individuals referred to it from the Wills Creek formation of Maryland, the striæ show a tendency to alternate in strength, although they do not display the difference in size seen in *S. hydraulica*. Some specimens from the Cobleskill of Buffalo, New York, display the same feature though perhaps in less degree. This species occurs in the Cobleskill of New York and in the Lucas dolomite of Ohio.

Length, 12 mm.; width, 17 mm.

Occurrence.—WILLS CREEK FORMATION. Flintstone. TONOLOWAY FORMATION. Quarry west of Hancock.

Collection.—Maryland Geological Survey.

SCHUCHERTELLA RUGOSA Swartz n. sp.

Plate XIX, Figs. 5-16

Description.—Shell subsemicircular, hinge-line straight, shorter than greatest width of shell, cardinal angles rounded; biconvex. Ventral valve more convex than dorsal valve, point of greatest convexity a little back of center, surface curving from it rapidly towards beak, less rapidly towards anterior margin, flat or slightly concave towards cardinal angles, posterior margin forming an obtuse angle over beak. Cardinal area triangular, its height one-quarter to one-third its width, its sides not symmetrical in most shells. Deltidium pronounced. Beak often unsymmetrically placed. Dorsal valve low, convex, point of greatest convexity back of center; umbo scarcely projecting back of hinge-line, which is straight. Surface concave between umbo and cardinal angles.

Surface of both valves ornamented by strong radial ribs, those in center straight, those near cardinal angles curving outwards. Ribs plate-like, separated by flat interspaces varying in thickness from point to point, their outer edges irregular, ragged in appearance. Primary ribs beginning at umbo; secondary ribs intercalated, shorter, about five in 3 mm. Surface crossed by indistinct fine concentric striæ. Some shells show concentric undulations due to interruptions in growth. (See figs. 8, 9.)

Interior of ventral valve shows shallow, indistinct depression for insertion of muscles. Two short rather stout teeth project from sides of deltidium. Interior of dorsal valve shows sockets corresponding to teeth of opposite valve, and a short indistinctly bifid cardinal process. This is an abundant species in the *Stenochisma lamellata* zone of the Tonoloway.

Dimensions of a large shell are 14 mm. long, 17 mm. wide.

Occurrence.—TONOLOWAY FORMATION. Pinto, Mullen's Quarry, Cumberland, National Road on Martin Mountain, Maryland; Keyser-Heddenville Road, Keyser, Quarry of Standard Lime and Stone Company, Keyser, Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Family PRODUCTIDAE

Subfamily CHONETINAE

Genus CHONETES Fisher

CHONETES NOVASCOTICUS Hall

Plate XIX, Figs. 17-22

Chonetes novascoticus Hall, 1860, Canadian Nat. Geol., vol. v, p. 144, fig. 2.
Chonetes novascoticus Dawson, 1878, Acadian Geol., 3d ed., p. 595, fig. 199.
Chonetes novascoticus Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., p. 155, pl. xxii, figs. 11-14.
Chonetes novascoticus Hall, 1882, 11th Rept. State Geol. Ind., p. 293, pl. xxii, figs. 11-14.
Chonetes cf. *nova-scotia* Clarke, 1913, Archivas Mus. Nac. Rio de Janeiro, vol. x, author's eng. ed., p. 12, pl. i, fig. 25.
Chonetes cf. *nova-scotia* Katzer, 1903, Grundz, d'Geol. d. unt. Amazonas, Leipzig, pl. xvi, fig. 8.

Description.—" Shell semielliptical, width varying from one and one-half to nearly twice the length. The ventral valve variably convex, and often showing a flattened or slightly concave space down the middle of the shell; cardinal margin ornamented by four or five minute spines on each side of the beak; cardino-lateral margins often a little wrinkled; surface finely striated, striæ flexuous, dichotomous, and increasing by interstitial additions, so that there are more than 100 on the margin of the shell; striæ increasing in size below the umbo; concentric striæ fine, close, rounded, and slightly undulating.

" Dorsal valve moderately concave, striæ much stronger below the middle of the shell and sometimes bifurcating toward the margin. Resembles

C. cornuta, but is larger and more ventricose. A stronger and more elevated striæ often mark the median line from beak to base of the ventral valve."—Hall, 1860.

This species as observed in Maryland is somewhat smaller than the forms figured from Nova Scotia and Indiana, and the forms found in the shales are more flattened than those from the limestones. The spines are not well preserved but give evidence, as a rule, of from three to five on a side. The striæ vary in number from 12 to 16 to the tenth of an inch. The surface markings and the general shape allow of the identification of the shell. The species occurs in the middle and upper beds of the Kirkland formation.

Length, 6 mm.; width, 10 mm.

Occurrence.—ROSE HILL FORMATION. Pinto, Cresaptown, Rose Hill, Cumberland, Flintstone, Maryland; Great Cacapon, West Virginia; Keefer Mountain, Pennsylvania.

Collection.—Maryland Geological Survey.

Superfamily PENTAMERACEA

Family PENTAMERIDAE

Genus CONCHIDIUM Linné

CONCHIDIUM CUMBERLANDICUM Prouty n. sp.

Plate XX, Fig. 8

Description.—This form is represented in the collection by the internal cast of a single pedicle valve which may be described as follows: Shell subrhomboidal, moderately convex, bearing a low, broad fold which has a width a little more than one-half that of the shell at the anterior border. Posterior margins straight, meeting at an obtuse angle over umbo. Anterior margin semicircular. Surface of cast marked by about 46 fine radiating lines, 18 of which occur on the fold. Faint concentric lines are visible at irregular intervals on the cast. Interior bears a median septum which extends one-third the way from back to anterior border.

Length, 13 mm.; breadth, 12 mm.

Occurrence—ROSE HILL FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

Genus GYPIDULA Hall

GYPIDULA ? sp.

Description.—Several internal casts of a species, possibly of *Gypidula*, have been observed in the Wills Creek formation which are characterized by a long median septum which seems to extend the entire length of the cast. They cannot be determined with confidence.

Occurrence.—WILLS CREEK FORMATION. Flintstone Creek.

Collection.—Maryland Geological Survey.

Order TELOTREMATA

Superfamily RHYNCHONELLACEA

Family RHYNCHONELLIDAE

Subfamily RHYNCHOTREMINAE

Genus STENOCHISMA Conard

STENOCHISMA (?) LAMELLATA (Hall)

Plate XX, Figs. 1-7

Atrypa lamellata Hall, 1852, Pal. N. Y., vol. ii, p. 329, pl. lxxiv, figs. 11a-h.
Rhynchonella lamellata Hall, 1859, 12th Rept. N. Y. State Cabinet Nat. Hist., p. 78.
Camarotoechia lamellata Grabau, 1909, N. A. Index Fos., vol. i, p. 286, fig. 349.
Camarotoechia ? lamellata Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 352, pl. lxiii, figs. 9, 10.

Description.—"Subrhomboidal, the ventral valve more convex; beak of the dorsal valve incurved, small, acute and prominent; surface marked by six or seven plications on each side of the mesial lobe and sinus, which are simple from their origin; mesial sinus marked by two plications, with three corresponding ones on the opposite valve (rarely three plications in the sinus, and four on the corresponding elevation); plications crossed by strong imbricating lamellæ, which are deeply arched, giving the surface a rugose aspect. This species bears a close resemblance to *Atrypa rugosa;* but all the specimens examined are nearly uniform in size, and not so large as the larger ones of that species. The plications are also simple from their origin, though marked by imbricating lamellæ much in the same manner."—Hall, 1852.

The specimens found in Maryland differ almost constantly from those described by Hall from New York in having one, rarely two, plications on the sinus, and two, rarely three, plications on the fold, while they have three or four, only rarely five, plications on each side of fold and sinus. Interior of dorsal valve bears two short, stout crura diverging from the umbo. Median septum absent or faintly developed.

The genus *Stenochisma* is regarded as the same as *Rhynchotrema* by Schuchert, while Grabau considers it distinct. *Stenochisma,* as defined by Clarke, lacks the strong median septum and cardinal processes in the dorsal valve which characterize *Rhynchotrema,* features which seem to the writer not unworthy of generic rank. This species has been assigned to various genera by different authors. Spirals are absent, hence it is not an *Atrypa,* while the genus *Rhynchonella* is probably not Paleozoic. The strong median septum and small spondylium, characteristic of the genus *Camarotoechia,* have not been detected in the individuals seen. It is hence referred somewhat questionably to the genus *Stenochisma.* It is very profuse locally about the middle of the Tonoloway formation, occurring also in the Keyser limestone.

Length, 16 mm.; width, 17 mm.

Occurrence.—TONOLOWAY FORMATION. Keyser-Heddenville Road, and Quarry of Standard Lime and Stone Company, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Genus UNCINULUS Bayle

UNCINULUS MARYLANDICUS Swartz n. sp.

Plate XX, Figs. 9-14

Description.—Shell subtrigonal, transverse, gibbous. Beak of ventral valve acute, incurved over dorsal valve, lateral margins nearly straight, meeting at a right angle over beak. Mesial sinus beginning a little back of middle of shell, becoming deep anteriorly. Dorsal valve very convex, subelliptical, center elevated into a fold which begins back of middle of shell and becomes high in front. Surface ornamented by low, broad plications, which are less distinct near beak; three, or more rarely four, plications occur in sinus; four, more rarely five, on fold; usually six or seven on each side of fold and sinus. Some plications bifurcate indistinctly. Strength of plications varies in same individual. The surface is also crossed by indistinct fine concentric striæ.

This species is characterized by its gibbous character, and by the plications becoming indistinct toward the umbo. It may be compared with *U. nucleolatus*, but is smaller, more transverse, not pentagonal. Its interior is unknown, rendering its generic relations insecure.

Length, 11 mm.; width, 13 mm.

Occurrence.—TONOLOWAY FORMATION. Grasshopper Run, West Virginia. WILLS CREEK FORMATION. Round Top, West Virginia.

Collection.—Maryland Geological Survey.

UNCINULUS OBSOLESCENS Swartz n. sp.

Plate XX, Figs. 15-19

Description.—Shell subtrigonal, transverse to equidimensional, thin biconvex. Ventral valve less convex than dorsal, its beak acute, elevated, slightly incurved, sides meeting nearly at right angles over beak. Anterior margin rounded, surface depressed anteriorly into a shallow sinus, which is indistinct in young individuals, more pronounced in older shells. Dorsal valve has nearly same shape as ventral, its beak being a little shorter and bearing a low median fold which may be indistinct in young individuals. Surface marked by low rounded plications of which about three are on fold, five on sides, becoming obsolescent towards umbo, distinct towards anterior margin. Plications bifurcate on fold in type specimen.

This species differs from *U. marylandicus* in being thin, not gibbous, and in having low plications which become obsolescent posteriorly. The material is scarcely adequate for a satisfactory description of the species. The interior is unknown.

Length, 9 mm.; width, 10 mm.

Occurrence.—TONOLOWAY FORMATION. Quarry west of Hancock. WILLS CREEK FORMATION. Flintstone Creek.

Collection.—Maryland Geological Survey.

UNCINULUS cf. STRICKLANDI (Sowerby)

Plate XX, Figs. 20-22; Plate XXI, Figs. 1-3

Terebratula stricklandi Sowerby, 1839, Murchison's Silurian System, pl. xiii, fig. 19.

Rhynchonella tennesseensis Hall (non Römer), 1860, Trans. Albany Institute, vol. iv, p. 228.

Rhynchonella tennesseensis Hall, 1876, 28th Rept. N. Y. State Mus. Nat. Hist., Doc. ed., pl. xxviii, figs. 34-40.

Rhynchonella stricklandi Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., Doc. ed., p. 165, pl. xxvi, figs. 34-40.

Rhynchonella tennesseensis White, 1880, 2d Ann. Rept. Indiana Bureau of Statistics and Geol., p. 496, pl. iii, figs. 2-4.

Rhynchonella stricklandi Hall, 1881, 11th Rept. State Geol. Survey Indiana, p. 308, pl. xxvi, figs. 34-40.

Rhynchonella stricklandi Nettleroth, 1889, Kentucky Fossil Shells, Mem. Ky. Geol. Survey, p. 81, pl. xxvii, figs. 9-11; pl. xxix, figs. 3-6.

Rhynchonella stricklandi Lesley, 1889, Geol. Survey Penn., Rept. P4, p. 901, figs.

Uncinulus (*Uncinulina*) *stricklandi* Hall and Clarke, 1895, Pal. N. Y., vol. viii, pt. 2, pl. lviii, figs. 38-40.

Description.—"Shell large, ovate, subtrigonal, very convex, sometimes wider than long, sides and front rounded. Dorsal valve very gibbous or ventricose, slightly flattened at the umbo; mesial fold wide, becoming very prominent as it approaches the front. Ventral valve less convex than the dorsal, beak small, closely incurved over the umbo of the opposite valve; sinus wide, flat, deep in front.

"Surface of each valve ornamented with from 25 to 34 simple, angular, radiating ribs, of which six or eight occupy the fold and sinus."—Hall, 1876.

There is a slight difference between the Maryland and the Waldron, Indiana, forms. The Maryland shells have perhaps a more marked sinus and in some of the larger and better preserved but exfoliated shells, some of the plications bifurcate near the front. This species is restricted to a thin zone in and above the Keefer sandstone.

The dimensions of two specimens are: Length, 23 mm.; width, 43 mm.; and length, 36 mm.; width, 43 mm. A gibbous shell is 33 mm. wide, and 23 mm. thick.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

UNCINULUS OBTUSIPLICATUS (Hall)

Plate XXI, Figs. 4-12

Atrypa obtusiplicata Hall, 1852, Pal. N. Y., vol. ii, p. 279, pl. lviii, fig. 2.

Rynchonella obtusiplicata Hall, 1859, 12th Rept. N. Y. State Cab. Nat. Hist., p. 78.

Camarotoechia obtusiplicata Hall and Clarke, 1893, Pal. N. Y., vol. viii, p. 190, pl. ii.

Camarotocchia obtusiplicata Grabau, 1901, Bull. N. Y. State Mus., vol. xlv, p. 193, fig. 106.

Camarotocchia obtusiplicata Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 193, fig. 106.

Description.—" Spheroidal or more or less gibbous; ventral valve extremely convex, beak of dorsal valve small, closely incurved over the ventral valve; surface plicated; plaits simple, rounded, about 18 to 20, three or four of which are depressed in the dorsal valve and projecting in front, filling a deep sinus in the margin of the ventral valve; a corresponding elevation on the ventral valve, which reaches from the base two-thirds of the way to the beak; plications crossed by fine subimbricating concentric striæ.

" The shell is easily distinguished from other species of this group by its rounded form and obtuse plications in the perfect shell, which are subangular in the cast. The proportion of the two valves is variable, the ventral one often becoming extremely convex, with the sinus in front greatly elevated. The number of plications varies from 16 to 22 in the greatest extremes of size; while three, and rarely four, are depressed on the one valve and four or five elevated on the opposite valve."—Hall, 1852.

The plications on the center fold of the pedicle valve of some individuals show a faint mesial groove. This feature is also noticeable in the type material suggesting their reference to the genus *Uncinulus*. The specimens from Maryland manifest much greater variation in their proportions than the type specimens in the Hall collection. Many of them, however, are identical in form.

The more flattened shells of this species resemble *Rhynchonella plicatella* of the New York Niagara. The great difference in shape among shells of this species would be sufficient for specific separation of the extreme members were not the gradation so complete between them.

This species is found about 40 feet below the top of the formation. The ratio of length to breadth to thickness in millimeters as observed in some adults is approximately 21 : 22 : 15. More gibbous forms give a ratio of 17 : 14 : 12. Young shells are very much less convex and have a shallow sinus, low fold and bear fewer plications. Their dimensions approximate 15 : 15 : 7 and 11 : 11 : 5. The forms show a continuous gradation from the gibbous to the most flattened forms.

Occurrence.—McKENZIE FORMATION. Pinto, Cedar Cliff, Flintstone, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Subfamily RHYNCHONELLINAE

Genus CAMAROTOECHIA Hall and Clarke

CAMAROTOECHIA ANDREWSI Prouty n. sp.

Plate XXI, Figs. 13-19

Description.—Shell lenticular to subspherical; outline subcircular; length and breadth approximately equal; thickness five-eighths as much in adult and three-eighths as much in young as other dimensions; small, rather obtuse plications, extending nearly to the beak, their number 28 to 36, normally about 30; sinus and fold markedly developed in mature forms, maximum height of fold observed 2.5 mm., normally 1.5 mm. Both the sinus and fold extend only about half-way to the beak, which is strongly incurved in both dorsal and ventral valves. Ventral beak is more elevated and narrower than dorsal beak over which it curves. Sinus bears from four to six plications, normally four, with often one or two less marked plications part way down the lateral sinal slopes; fold with five to seven plications, usually five, sometimes one or two less marked plications appear on lateral slope of fold. The young forms have practically the same number of plications as the mature, but the shell is less gibbous, the beaks are straighter and the sinus and fold are undeveloped or very shallow.

This fossil occurs in great abundance throughout the Maryland area in a zone some 50 feet thick, which extends to within about 40 feet of the top of the McKenzie.

Three normal adults show:

Length	Breadth	Width
12.0 mm.	12.0 mm.	7.0 mm.
13.0 mm.	12.0 mm.	9.0 mm.
12.0 mm.	12.5 mm.	8.5 mm.

Three younger shells show:

Length	Breadth	Width
9.5 mm.	9.5 mm.	4.0 mm.
7.5 mm.	7.0 mm.	3.0 mm.
5.0 mm.	4.5 mm.	2.0 mm.

Occurrence.—McKENZIE FORMATION. At all exposures of the upper beds of the formation in Maryland.

Collection.—Maryland Geological Survey.

CAMAROTOECHIA (?) NEGLECTA (Hall)

Plate XXI, Figs. 20-22

Atrypa neglecta Hall, 1852, Pal. N. Y., vol. ii, p. 70, pl. xxiii, fig. 4; p. 274, pl. lvii, fig. 1.

Atrypa neglecta Billings, 1856, Canadian Nat. Geol., vol. i, p. 138, pl. ii, figs. 11, 12.

Rhynchonella neglecta Hall, 1859, 12th Rept. N. Y. State Cab. Nat. Hist., p. 78.

Rhynchonella neglecta Billings, 1863, Geol. Canada, p. 315, fig. 325.

Rhynchonella neglecta var. *scobina* Meek, 1872, Amer. Jour. Sci., 3d ser., vol. iv, p. 277.

Rhynchonella neglecta Meek, 1873, Pal. Ohio, vol. i, p. 179, pl. xv, fig. 3.

Rhynchonella neglecta Hall and Whitfield, 1875, Pal. Ohio, vol. ii, p. 134, pl. vii, fig. 15.

Rhynchonella scobina Hall and Whitfield, 1875, Pal. Ohio, vol. ii, p. 116.

Rhynchonella neglecta Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., p. 162, pl. xxvi, figs. 1-6.

Rhynchonella neglecta Hall, 1882, 11th Rept. State Geol. Indiana, p. 305, pl. xxvi, figs. 1-6; pl. xxvii, fig. 3.

Rhynchonella neglecta Beecher and Clarke, 1889, Mem. N. Y. State Mus. vol. i, p. 37, pl. iv, figs. 3, 6-8.

Rhynchonella neglecta Foerste, 1890, Proc. Boston Soc. Nat Hist., vol. xxiv, p. 317, pl. vi, fig. 12.

Rhynchonella scobina Foerste, 1895, Geol. Ohio, vol. vii, p. 592.

Camarotoechia ? neglecta Hall and Clarke, 1895, Pal. N. Y., vol. viii, pt. 2, p. 190.

Camarotoechia (?) neglecta Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 193, fig. 107.

Description.—" Subpyramidal or subglobose, the beak more or less elevated ; valves very gibbous below, and tapering very abruptly to the beaks ; mesial depression and elevation moderate, marked in the dorsal valve by three and in the ventral valve by four plications ; valves on each side of the mesial fold marked by from five to nine plications, which are angular and undivided to the beak ; surface marked by undulating or zig-zag striæ, which are usually obsolete ; cardinal line not extended ; beak of dorsal valve sometimes closely incurved, and in other specimens elevated and slit beneath the apex.

" Species in the Niagara is never as gibbous or rotund, but has a more triangular outline."—Hall, 1852.

Length, 9 mm. ; breadth, 9 mm. ; thickness, 7 mm.

Occurrence.—ROCHESTER FORMATION. Abundant throughout Maryland area. ROSE HILL FORMATION. Pinto, Cumberland, Six-mile House, Flintstone, Maryland ; Keefer Mountain, Pennsylvania. TUSCARORA FORMATION. Cumberland, east end of Narrows, in shale partings in uppermost beds.

Collection.—Maryland Geological Survey.

CAMAROTOECHIA LITCHFIELDENSIS (Schuchert)

Plate XXII, Figs. 1-6

Atrypa sp. Hall, 1852, Pal. N. Y., vol. ii, p. 330, pl. lxxiv, figs. 1, 12.

Rhynchonella agglomerata Weller, 1903, Geol. Survey N. J., Pal., vol. iii, pp. 234, 235, pl. xxi, figs. 5-11.

Rhynchonella ? litchfieldensis Schuchert, 1903, Amer. Geol., vol. xxi, p. 167, figs.

Camarotoechia litchfieldensis Grabau, 1906, Bull. N. Y. State Mus., 92, p. 109, fig. 14.

Camarotoechia litchfieldensis Grabau, 1909, North Amer. Index Fos., vol. i. p. 286, fig. 350.

Camarotoechia litchfieldensis Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 353, pl. lxiii, figs. 11-14.

Description.—"Shell subtriangular, usually a little wider than long, the valves subequally convex, the postero-lateral margins tapering to the beak, where they form an angle of about 90°; the lateral and anterior margins rounded. Pedicle valve most prominent near the umbo, the beak sharply pointed, arched over that of the opposite valve; mesial sinus rather shallow, rounded in the bottom, not extending back to the center of the valve. Brachial valve most prominent at and in front of the middle; mesial fold not conspicuous, except near the front margin. Each valve marked by from 18 to 22 simple, angular plications, three of which are usually included in the sinus of the pedicle valve. The finer markings of the shell, if they were present, have been obliterated by exfoliation. The dimensions of an average adult specimen are: Length, 9 mm.; width, 9.5 mm.; thickness, 5.5 mm."—Weller, 1903.

This species is characterized by small size, fine plications, shallow sinus, and low fold. The typical form has from eight to nine plications on each side of the fold and sinus. The Maryland shells have usually about six plications on each side of the fold and sinus, in which respect they closely approach *C. neglecta* of the Clinton and Niagara. They differ from the latter in having a somewhat shallower sinus and lower fold, while the plications are not crossed by strong, concentric striæ. The latter feature seems to be the most decisive difference. The author has specimens of *C. neglecta* from the Rochester shale of New York which scarcely differ specifically from the Maryland forms. The Tonoloway shells tend to be narrower than those from the Wills Creek formation. The latter shells agree more closely with those described by Weller.

This is a characteristic species of the Cobleskill of New York, where it has frequently been referred to *C. neglecta*. It occurs at several horizons in the Wills Creek and is abundant in the Tonoloway and overlying Keyser limestone.

Length, 8 mm.; width, 9 mm.[1]

[1] Schuchert's original figures are greatly enlarged, although that fact is not indicated in the accompanying text.

Occurrence.—TONOLOWAY FORMATION. At all localities. WILLS CREEK FORMATION. Pinto, Flintstone Creek, Round Top, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

CAMAROTOECHIA LITCHFIELDENSIS var. MARYLANDICA Swartz n. var.

Plate XXII, Figs. 7-13

Description.—Shells trigonal, transverse, valves subequally convex, lateral margins concave, antero-lateral angles rounded, anterior margin slightly convex or truncate, ventral valve with acute beak, slightly incurved over dorsal valve; sinus beginning in front of beak and widening rapidly towards front where it becomes deep. Dorsal valve bearing a fold which becomes high in front. Surface of both valves ornamented by high, compressed, subangular plications of which three are usually in sinus and six to eight each side. The plications curve laterally in approaching the front, causing the interspaces to become wide in front in older shells.

This variety is characterized by its acute beak, subangular curved plications, sinus wide and pronounced in front, transverse habit, moderate size. It is larger and differs so much in its expression from *C. litchfieldensis* that were it not for a few transitional shells it would be justly described as a distinct species.

Length, 8 mm.; width, 8 mm.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain, Maryland; Quarry of Standard Lime and Stone Company, Keyser, Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

CAMAROTOECHIA TONOLOWAYENSIS Swartz n. sp.

Plate XXII, Figs. 14-20

Description.—Shell subtrigonal, usually transverse, less frequently length and width subequal, valves subequally convex, lateral margin slightly concave near beak, rounding at antero-lateral angles, front slightly curved or nearly straight. Ventral valve more convex at umbo.

beak sharply pointed and slightly incurved over opposite valve. Mesial sinus beginning near beak, widening and deepening anteriorly. Dorsal valve with beak sharply incurved, bearing a fold which begins near beak and becomes prominent anteriorly. Surface of both valves marked by simple plications separated by broader concave interspaces, three to four plications occurring in sinus, four to five on fold, and seven to eight on each side of sinus and fold. The plications are rounded, crossed by concentric striæ, and bear numerous imbricating lamellæ anteriorly in most shells. The sinus is not very deep in young shells, but becomes increasingly pronounced with age, being deep in old individuals with corresponding elevation of the fold on the opposite valve.

This species differs from *C. litchfieldensis* in being larger, older individuals having deep sinus and high fold, and in having imbricating lamellæ which cross plications anteriorly. It resembles *C. neglecta,* but its plications are less angular and more numerous. Its relation to the latter species, however, is close.

Length, 10 mm.; width, 12 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, Cumberland, National Road on Martin Mountain, Quarry west of Hancock, Lanes Run, Maryland; Keyser-Heddenville Road and Quarry of Standard Lime and Stone Company, Keyser, Grasshopper Run, West Virginia; Hyndman, Pennsylvania. WILLS CREEK FORMATION. Flintstone Creek.

Collection.—Maryland Geological Survey.

Superfamily SPIRIFERACEA

Family ATRYPIDAE

Subfamily ATRYPINAE

Genus ATRYPA Hall and Clarke

ATRYPA RETICULARIS (Linné)[1]

Plate XXI, Figs. 24, 25

Anomia reticularis Linné, 1767, Systema Naturæ, ed. xii, vol. i, p. 1132.

Atrypa reticularis Hall, 1852, Pal. N. Y., vol. ii, p. 72, pl. xxiii, fig. 8; p. 270, pl. lv, fig. 5.

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[1] For the extended synonymy of this species see Bassler, Bull. U. S. Nat. Museum, No. 92, 1915, vol. ii, pp. 93, 94.

Atrypa reticularis Beecher and Clarke, 1889, Mem. N. Y. State Mus. Nat. Hist., vol. i, p. 51, pl. iv, figs. 12-20.

Atrypa reticularis Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, p. 165, fig. 153; pl. lv, figs. 1-17.

Description.—"Shell subrotund, more or less compressed, subtruncated above on the hinge-line; valves more or less equal, the beak of the dorsal valve extending beyond the ventral valve, and the latter being deeper and more convex in older specimens; surface marked by dichotomous, rounded striæ, which are crossed by concentric, elevated lamellæ, giving a reticulated or decussated character to the surface.

"It is impossible to give a definite description of this very protean species, which commences its existence in the Clinton group and continues with various modifications as far as the Chemung. In each of its geological positions, however, it presents peculiar characters and we are able to decide at once the geological position of specimens by their peculiarities.

"On its first appearance in the Clinton group, it shows its variable character in a remarkable degree, and it is scarcely possible to avoid referring the individuals to distinct species. In many of the young specimens, the ventral valve is nearly flat, or slightly convex, with a depression along the center from beak to base. In specimens of medium size the valves are nearly equal and in older ones the ventral valve is the more convex. Again there are others where, in the young shell the ventral valve has no depression in the center, and is equally convex with the dorsal valve. In the radiating striæ or plications it is equally variable; many specimens have them very distinctly dichotomous, while others are nearly undivided from the beak. In many young shells the concentric striæ leave the plications nodulose at their crossing; while there are specimens having the plications quite free from such characters, and entirely smooth."—Hall, 1852.

None of the Clinton forms from Maryland show marked extensions of the concentric lamellæ, but nearly all have comparatively fine plications, their number being 24 to 30 before branching.

Length, 16 mm.; width, 15 mm.; thickness, 9 mm.

Occurrence.—ROCHESTER FORMATION. A common fossil in the upper beds throughout the Maryland area. ROSE HILL FORMATION. Rose Hill, Cumberland.

Collection.—Maryland Geological Survey.

Family SPIRIFERIDAE

Subfamily SPIRIFERINAE

Genus SPIRIFER Sowerby

SPIRIFER MCKENZICUS Prouty n. sp.

Plate XXII, Figs. 21-30

Description.—Hinge-line more or less extended; pedicle valve strongly arcuate with beak extended and incurved, bearing a deep sinus which, like the fold on the brachial valve, is equal in width to four of the radiating plications; shell marked by from four to ten rather low rounded plications on each side of the sinus and fold, their number varying with age. The exfoliated forms show a faint mesial depression of the fold toward the beak. Surface of shell marked by rather fine, lamellose, concentric striæ which number about five to the millimeter in specimens of average size.

This species resembles several described species. From *S. sulcata* of the Niagara of New York, Ontario, and Europe, it differs mainly in possessing much less prominent concentric striæ; from *S. cycloptera* of the Helderberg it differs chiefly in its more numerous plications and greater proportionate breadth; from *S. submucronatus* it differs chiefly in its wider fold and sinus. It occurs from about 35 to 70 feet below the top of the McKenzie, being found in great numbers about 40 feet below the top.

Average dimensions of brachial valve: Length, 11 mm.; width, 20.5 mm. Of a pedicle valve: Length, 21 mm.; width, 24 mm.

Occurrence.—MCKENZIE FORMATION. Pinto, Cedar Cliff, Flintstone, Rabble Run, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Subgenus DELTHYRIS Dalman

SPIRIFER (DELTHYRIS) CRISPUS (Hisinger)

Plate XXIII, Figs. 1-4

Spirifer crispus Hall, 1852, Pal. N. Y., vol. ii, p. 262, pl. liv, fig. 3.
Spirifer crispus Grabau, 1901, Buffalo Soc. Nat. Sci. Bull., vol. vi, p. 199, fig. 118.
Delthyris crispa Dalman, 1828, Köngl. Vet. akad., p. 122, pl. iii, fig. 6.
Delthyris staminea Hall, 1853, Geol. N. Y., Rept. 4th Dist., p. 105, fig. 3.
Spirifer staminea Emmons, 1860, Manual Geol., p. 109, fig. 99.

Description.—" Shell subrhomboidal (ventral valve semicircular), gibbous; valves very unequal, the dorsal one extremely convex, and the beak extended and incurved; surface marked by five or six, rarely eight, plications on each valve, which are sometimes obsolete, concentrically marked by fine elevated thread-like striæ; area broad, with the cardinal extremities short; foramen long, narrow."—Hall, 1852.

The width of the foramen is a quite variable feature, as is shown by Hall's figures and by those of other authors. The Maryland specimens also show a wider foramen than the description implies. Maryland forms resemble those figured from Indiana more closely than those from New York.

Two pedicle valves measure, respectively: Length, 12 mm.; width, 18 mm.; and length, 12 mm.; width, 19 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Flintstone.

Collection.—Maryland Geological Survey.

SPIRIFER (DELTHYRIS) VANUXEMI Hall

Plate XXIII, Figs. 5-9

Orthis plicata Vanuxem, 1842, Geol. N. Y., Rept. 3d Dist., p. 112, fig. 1.
Orthis plicata Mather, 1843, Nat. Hist. N. Y. Geol., vol. i, p. 349, fig. 1.
Orthis plicatus Hall, 1843, Geol. N. Y., 4th Dist., p. 142, fig. 1.
Delthyris plicatus Owen, 1846, Amer. Jour. Sci., 2d ser., vol. i, p. 46, fig. 1.
Spirifer vanuxemi Hall, 1859, Pal. N. Y., vol. iii, p. 198, pl. viii, figs. 17-23, 1861.
Spirifer vanuxemi Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, pp. 19, 36, pl. xxxvi, fig. 11.

Spirifer vanuxemi Whitfield, 1895, Geol. Ohio, vol. vii, p. 411, pl. i, figs. 4, 5.
Spirifer vanuxemi Sherzer, 1900, Mich. Geol. Survey, vol. vii, pt. 1, p. 223, pl. xvii, figs. 3, 4, 5.
Spirifer vanuxemi Grabau, 1903, Bull. N. Y. State Mus., vol. lxix, p. 1040, fig. 5.
Spirifer vanuxemi Weller, 1903, Geol. Survey N. J., Pal., vol. iii, p. 202, pl. xxiv, figs. 9-12.
Spirifer vanuxemi Grabau, 1906, Bull. N. Y. State Mus., vol. lxxx, p. 240, fig. 24.
Spirifer vanuxemi Grabau and Shimer, 1907, N. A. Index Fos., vol. i, p. 320, fig. 403.
Spirifer vanuxemi Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 403, pl. lxviii, figs. 32, 33.
Spirifer (Delthyris) vanuxemi Bassler, 1915, Bull. U. S. Nat. Mus., No. 92, vol. ii, p. 1179.

Description.—"Shell rhomboidal, moderately gibbous; extremities rounded. Ventral valve the less convex, having the beak elevated and incurved. Area small. Surface marked by broad rounded or somewhat flattened and sometimes undefined plications, of which there are from two to four on each side of the mesial fold and sinus; concentrically marked by fine closely arranged undulating striæ and stronger imbricating lines of growth, which are again crossed by still finer radiating striæ; the latter visible only under a magnifier."—Hall, 1859.

This species is characterized by its small size, subrhomboidal outline, elevated beak, rather narrow cardinal area, which passes into the posterior surface of the shell by a rounded distinctly plicate surface.

The specimens referred to this species in the Wills Creek formation of Maryland have generally three plications on each side of the fold or sinus, and the dorsal median fold is usually flattened or bears a faint groove in the center.

This species appears to be restricted to the Manlius formation in New York. In Maryland it has a much greater range, being found in the Wills Creek and also in the lower part of the Keyser limestone. The specimens here described seem indistinguishable from those found in the Manlius of New York.

Length, 6 mm.; width, 8 mm.; thickness, 5 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, National Road on Martin Mountain, Maryland; Grasshopper Run, West Virginia. WILLS CREEK FORMATION. Pinto, Flintstone Creek, Round Top, Maryland.

Collection.—Maryland Geological Survey.

SPIRIFER (DELTHYRIS) VANUXEMI var. TONOLOWAYENSIS Swartz n. var.

Plate XXIII, Figs. 10, 11

Description.—Individuals occurring in the Tonoloway formation differ from the typical shells in having fewer and more numerous plications, four to five being present on each side of the fold and sinus; plications less pronounced than is usual in the typical shells, becoming obsolete near the cardinal angles. This form differs but slightly from *S. vanuxemi* var. *prognostica,* found in the Keyser limestone of the overlying Helderberg formation, the plications of the latter variety being somewhat stronger and more angular. It resembles very closely a variety of *S. vanuxemi* found in the basal nodular beds of the Keyser limestone (see Pl. XXIII, Fig. 12, where a figure of the latter is introduced for comparison), the latter differing chiefly in having somewhat coarser ribs.

Length, 7 mm.; width, 8 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, Mullen's Quarry, Cumberland.

Collection.—Maryland Geological Survey.

SPIRIFER (DELTHYRIS) KEYSERENSIS Swartz n. sp.

Plate XXIII, Figs. 13, 14

Description.—Shell subrhomboidal, transverse, length about three-quarters the width. Ventral valve gibbous, much more convex than dorsal valve; its beak high, incurved over area; cardinal angles rounded, hinge-line short; sinus angular, widening regularly from beak towards front. Dorsal valve subelliptical, low convex, cardinal angles rounded, fold about twice as wide as plications adjacent to it, flat or bearing anteriorly a faint median groove. Surface of ventral valve bearing on each side of sinus four to five plications which show a tendency to be flattened or even to bear a faint groove anteriorly; dorsal valve having on each side of fold about five low rounded plications separated by narrower interspaces; entire surface crossed by faint concentric striæ.

The specimens found in Maryland are all preserved in a calcareous shale and are hence probably somewhat crushed or flattened. Individuals probably of the same species, found in Pennsylvania by J. B. Reeside, Jr.,[1] in hard limestone have much more strongly incurved beak and are strongly fimbriate punctate.

This species closely resembles *S. ohioensis* Grabau from the Put-in-Bay dolomites of northern Ohio and Michigan, but differs in having less pronounced plications and a more gibbous ventral valve. The dorsal valves of these species closely resemble each other. It also closely approaches *S. modestus* var. *plicatus* Maynard and *S. eriensis* Grabau, but differs in having much stronger plications. It also suggests *S. vanuxemi* but is much larger. This is one of a closely related group of shells probably derived from *S. crispus*, which may be tabulated as follows:

	Nearly smooth	Slightly plicate	Well plicate
Small....	*S. corallinensis.*	*S. eriensis.*	*S. vanuxemi.*
Large....	*S. modestus.*	*S. modestus* var. *plicatus.*	*S. keyserensis* less strongly plicate. *S. ohioensis* more strongly plicate.

Most of these species are more or less closely connected by intergrading forms making their separation difficult. *S. crispus* differs from them in having a wider and more sharply limited cardinal area, and in having strong concentric striæ crossing its distinct plications. *S. keyserensis* appears to be restricted to the upper beds of the Tonoloway formation.

Length, 13 mm.; width, 17 mm.

Occurrence.—TONOLOWAY FORMATION. Quarry of Standard Lime and Stone Company, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

[1] Reeside, J. B., The Helderberg limestone of Central Pennsylvania, U. S. Geol. Survey, Prof. Paper 108, 1907, p. 188.

SPIRIFER (DELTHYRIS) CORALLINENSIS Grabau

Plate XXIII, Figs. 15-18

Spirifer crispus Hall, 1852 (non Hisinger), Pal. N. Y., vol. ii, p. 328, pl. lxxiv, figs. 9a-h.

Spirifer crispus var. *coralliensis* Grabau, 1900, Bull. Geol. Soc. Amer., vol. xi, p. 352.

Spirifer crispus var. *corallinensis* Grabau, 1901, Bull. 45, N. Y. State Mus., p. 199.

Spirifer crispus Clarke and Ruedemann, 1903, Mem. 5, N. Y. State Mus., p. 42, pl. iv, figs. 11-20.

Spirifer corallinensis Grabau, 1903, Bull. 69, N. Y. State Mus., p. 1042, fig. 6.

Spirifer modestus var. *corallinensis* Schuchert, 1903, Amer. Geol., vol. xxxi, p. 166.

Spirifer corallinensis Grabau, 1906, Bull. 92, N. Y. State Mus., p. 108, fig. 10; p. 115, fig. 20.

Spirifer corallinensis Grabau and Shimer, 1909, N. A. Index Fos., vol. i, p. 320, fig. 405.

Spirifer corallinensis Foerste, 1909, Cincinnati Soc. Nat. Hist., Jour. vol. xxi, p. 18.

Spirifer (Delthyris) corallinensis Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. ii, p. 1172.

Description.—"This differs from the normal *S. crispus* of the Niagara in its uniformly obsolescent plications and angular medial sinus, characters which most strongly ally it to *S. eriensis*."—Grabau, 1900.

It may be further described as follows: Shell small, subrhomboidal, transverse, cardinal angles rounded. Ventral valve gibbous, its surface concave near cardinal angles, beak elevated, incurved over area, which is narrow. Dorsal valve semielliptical, convexity slight. Surface of ventral valve ornamented by a narrow mesial sinus, on each side of which one or two faint plications may occur. Dorsal valve has a broad, low mesial fold, remainder of valve being smooth.

This species is characterized by its small size, very unequal convexity of ventral and dorsal valves, and by its nearly smooth surface, save for fold and sinus. Apart from its small size it closely resembles *S. modestus,* of which species it was made a variety by Schuchert in 1903. The individuals referred to this species in Maryland are restricted to the uppermost beds of the Tonoloway. They are rare and their condition of preservation renders their identification not wholly free from doubt.

Length, 10 mm.; width, 11 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, National Road on Martin Mountain, Maryland; Quarry of Standard Lime and Stone Company, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Subgenus EOSPIRIFER Schuchert

SPIRIFER (EOSPIRIFER) RADIATUS Sowerby[1]

Plate XXIII, Figs. 19, 20

Spirifer plicatella var. *radiata* Sowerby, 1825, Mineral Conchology, vol. v, p. 493, figs. 1, 2.

Delthyris bialveata Conrad, 1842, Jour. Acad. Nat. Sci., Phila., p. 261, pl. xiv, fig. 17.

Delthyris radiata Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 105, fig. 2.

Spirifer radiata Hall, 1852, Pal. N. Y., vol. ii, pp. 66, 265, pl. xxii, figs. 2d-25 (non 2a-2c = *Cyrtia meta*); pl. liv, fig. 6.

Spirifer radiata Hall, 1882, 11th Rept. State Geol. Indiana, p. 296, pl. xxiv, figs. 20-30.

Spirifer radiatus Beecher and Clarke, 1889, Mem. N. Y. State Mus., vol. i, p. 77, pl. vi, figs. 9-11.

Spirifer radiatus Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, pp. 13, 35, pl. xxi, figs. 5, 9-13, 26 (? 14-18).

Spirifer radiata Kindle and Breger, 1904, Ind. Dept. Geol. and Nat. Res., 28th Ann. Rept., p. 442, pl. viii, fig. 19.

Description.—" Shell variable in form, subtriangular, rotund or subglobose; valves almost equally convex, the beak of the dorsal valve more or less extended, and curving over the ventral valve; hinge line often less than the width of the shell, the extremities being rounded; surface marked by fine, close, radiating striæ; mesial elevation and depression moderate, marked by the striæ as other parts of the shell; dorsal area more or less exposed, and giving a very variable appearance to the shell; foramen narrow and long, often partially or entirely closed by a callosity; interior plates of the dorsal valve near together, and extending downwards within the limits of the mesial depression.

" The beaks of the two valves are often so closely approximated that no area is visible; and at the same time the extremities are rounded and con-

[1] For the extended synonymy of this species see Bassler, U. S. Nat. Mus., Bull. 92, vol. ii, 1915, p. 1176.

tracted, so that the shell has more the appearance of an *Atrypa* than a *Spirifer*. In others the extremely wide dorsal area gives one the impression that there is a species having this constant character, and quite distinct from those with the moderate area and rounded extremities. After examining numerous specimens, I am able to see no distinction, and the numerous intermediate forms unite the whole as a single species."—Hall, 1852.

Only one small specimen which has moderate area and rounded extremities was observed from Maryland. This specimen has a tendency toward the plicatella form. (Fig. 50, Hall and Clarke.)

Length of pedicle valve of small individual, 10 mm.; width, 14 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland. ROSE HILL FORMATION. Flintstone.

Collection.—Maryland Geological Survey.

SPIRIFER (EOSPIRIFER) EUDORA Hall

Plate XXIII, Figs. 21-25

Spirifer eudora Hall, 1861, Ann. Rept. Geol. Survey Wis., p. 25.

Spirifer eudora Hall, 1863, Geol. Survey Wis., vol. i, p. 69, pl. v; p. 436.

Spirifer eudora Hall, 1863, Trans. Albany Inst., p. 211.

Spirifer eudora Hall, 1867, 20th Rept. N. Y. State Cab. Nat. Hist., p. 13, figs. 5, 7.

Spirifer eudora Hall, 1879, 28th Rept. N. Y. State Cab. Nat. Hist., p. 156, pl. xxiv, figs. 13-18.

Spirifer eudora Hall, 1882, 11th Rept. State Geol. Survey Ind., p. 294, pl. xxiv, figs. 13-18.

Spirifer eudora Hall, 1883, 2d Ann. Rept. N. Y. State Geol., pl. li, figs. 19-21, 29.

Spirifer eudora Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, pp. 13, 35, pl. xxi, figs. 19-21, 29.

Description.—"Shell of moderate size, transversely subovate, length as three to four, valves extremely gibbous, hinge-line less than width of shell below, cardinal extremities rounded; area moderately high, foramen triangular, a little higher than wide, surface marked by three to four simple, strong, angular plications on each side of the mesial fold and sinus.

Dorsal valve regularly arcuate, beak somewhat incurved; mesial fold of moderate width, flattened above and slightly depressed in the lower part. Ventral valve most prominent near the umbo, beak strongly incurved over the area, mesial sinus broad and deep.

"The minute surface markings, as shown in specimen from Waldron, are fine radiating striæ practically like those of *S. macropleura* of the Lower Helderberg group of New York."—Hall, 1882.

The dimensions of a pedicle valve are: Length, 22 mm.; width, 26 mm.; thickness, 7 mm.

Occurrence.—ROCHESTER FORMATION. Flintstone, Maryland. ROSE HILL FORMATION. Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

SPIRIFER (EOSPIRIFER) NIAGARENSIS (Conrad)

Plate XXIII, Fig. 26

Delthyris niagarensis Conrad, 1842, Jour. Acad. Nat. Sci., Phila., vol. viii, p. 261.

Delthyris niagarensis Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 105, fig. 1.

Spirifer niagarensis Hall, 1852, Pal. N. Y., vol. ii, p. 264, pl. liv, fig. 5.

Spirifer niagarensis Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, pp. 14, 35, pl. xxi, figs. 1-4, 25; pl. xxxvii, fig. 1.

Spirifer niagarensis Billings, 1856, Canadian National Geol., vol. i, p. 137, pl. ii, fig. 8.

Spirifer niagarensis Billings, 1863, Geol. Canada, p. 317, fig. 329.

Spirifer niagarensis Hall, 1883, 2d Ann. Rept. N. Y. State Geol., p. 51, figs. 1-4, 25.

Description.—"Of moderate size, convex with nearly equal valves. Pedicle valves with strongly incurved beak. Surface covered with many fine depressed plications which become obsolete toward the extremities and sometimes appear quite flattened out. Fine, thread-like radiating striæ cover plication and interspaces alike."—Grabau, 1909.

Only one specimen has been observed in the Maryland rocks and this is a fragment, but the character of the ornamentation warrants the identification.

A restoration from the fragment shows the shell to have a width of more than 40 mm.

Occurrence.—ROCHESTER FORMATION. Flintstone.

Collection.—Maryland Geological Survey.

Subfamily RETICULARIINAE

Genus RETICULARIA M'Coy

RETICULARIA BICOSTATA (Vanuxem)

Plate XXIV, Figs. 1-5

Orthis bicostatus Vanuxem, 1842, Geol. N. Y., Rept. 3d Dist., pp. 91, 94.
Spirifer bicostatus Hall, 1852, Pal. N. Y., vol. ii, p. 263, pl. liv, fig. 4.
Spirifer bicostata Hall, 1883, 2d Ann. Rept. N. Y. State Geol., pl. lxi, fig. 7.
Spirifer bicostatus Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, pp. 19, 37, pl. xxxvi, fig. 7.

Description.—" Somewhat ovate-triangular, the dorsal valve gibbous, with the beak extended and incurved over a short triangular area; ventral valve convex; surface marked by conspicuous, concentric, subimbricating striæ; dorsal valve with a distinct plication on each side of the sinus, and toward the base are two other obscure plications on each side, presenting three and sometimes four gentle undulations on the margin on each side of the center; cardinal line shorter than the width of the shell, and the area scarcely extending so far as the cardinal line; extremities distinctly rounded."—Hall, 1852.

This form closely resembles *Spirifer crispus,* from which it is distinguished by its fewer and less marked plications, short hinge-line, and the abrupt curvature of its subimbricating striæ at their extremities.

Three pedicle valves measure, respectively: Length, 24 mm.; width, 29 mm.; length, 15 mm.; width, 18.5 mm.; length, 11 mm.; width, 13.5 mm.; thickness, 5 mm. A brachial valve measures: Length, 17 mm.; width, 25 mm.

Occurrence.—McKENZIE FORMATION. Pinto, Six-mile House, Maryland. ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House, east of Tonoloway, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

RETICULARIA BICOSTATA var. MARYLANDICA Prouty n. var.

Plate XXIV, Figs. 6-15

Description.—This form differs from the typical form in showing greater retardation in the development of its plications, most forms having only a weak sinus and fold, with faint if any side plications.

Length, 16 mm.; width, 14 mm.

Occurrence.—McKENZIE FORMATION. Pinto, Cumberland, Six-mile House, Maryland. ROCHESTER FORMATION. Rose Hill, Cumberland, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

Family RHYNCHOSPIRIDAE

Genus RHYNCHOSPIRA Hall

RHYNCHOSPIRA GLOBOSA (Hall)

Plate XXIV, Figs. 16-25

Waldheimia globosa Hall, 1857, 10th Ann. Rept. N. Y. State Cab. Nat. Hist., p. 87.

Trematospira globosa Hall, 1859, Pal. N. Y., vol. iii, p. 215, pl. xxxvi, figs. 1a-p.

Rhynchospira globosa Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, p. 111.

Rhynchospira globosa Schuchert, 1913, Md. Geol. Survey, Lower Dev., p. 425, pl. lxxii, figs. 16-25.

Description.—" Shell subglobose or ovoid. Ventral valve a little larger and slightly less gibbous than the opposite one, most gibbous in the umbonal region; beak prominent, rounded and arched, perforate at the extremity by a round aperture, the lower side of which is formed by a deltidium. Dorsal valve shorter than the ventral, very gibbous in the middle; beak incurved. Surface marked by 12 to 16 somewhat angular plications on each valve, two or three of which are slightly depressed on the middle so as to produce, sometimes, a faint emargination in front; the depressed plications smaller than the others, and often becoming obsolete before reaching the beak. A few strong, concentric imbricating lines of growth cross the plications; shell gradulose."—Hall, 1859.

The shells occurring in the Tonoloway formation in Maryland agree with those of the New York New Scotland in essential respects, save that they are somewhat less globose. This species is also abundant in the basal beds of the overlying Keyser limestone where the shells have in general finer plications than those of the New York New Scotland which closely resemble those of the Tonoloway. The species occurs profusely locally about the middle of the Tonoloway, but are usually crushed.

Length of shell of medium size, 10 mm.; width, 10 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, Mullen's Quarry, Cumberland, National Road on Martin Mountain, Maryland; Keyser-Heddenville Road and Quarry of Standard Lime and Stone Company, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Genus HOMŒOSPIRA Hall and Clarke

HOMŒOSPIRA EVAX var. MARYLANDICA Prouty n. var.

Plate XXV, Figs. 1-9

Description.—"Shell ovate, often broadly ovate, usually longer than wide, sometimes much longer; both valves gibbous in the middle and upper part, ventral valve a little deeper than the opposite, both valves sometimes marked by a shallow undefined sinus, causing an emargination in front. Ventral beak much elevated above the other, and incurved, so as to bring the plane of the foramen parallel to the axis of the shell; foramen distinctly rounded with a visible triangular space below which is occupied by two small deltidial plates. Dorsal valve regularly arcuate, except near the front; beak loosely incurved beneath the deltidial plates of the opposite valve. In some specimens there is a broad undefined mesial elevation on the lower part of the valve including about five or six plications besides the central one, which is divided into two or three smaller ones (a generic feature). Sometimes there is a broad, undefined depression and frequently only a narrow depression caused by the subdivided central plication. The ventral valve has uniformly a longitudinal sinus, which includes two or three plications arising from a subdivision of the central one and sometimes including one or two on each side.

"The shell is marked by radiating rounded or subangular costæ or plications, from eight to fourteen on each side of the central one; those on the cardinal slopes sometimes bifurcating or with interstitial additions, while in a few individuals bifurcating costæ occur on the other parts of the valve; the interspaces are rounded grooves of about the same size as the plications. The surface is marked by fine, concentric striæ and stronger, unbifurcating lamellose lines of growth."—Hall, 1879.[1]

This variety differs from the typical form mainly in having usually a greater breadth near the beak. There is a tendency also for the brachial valve to bear a low fold instead of a shallow sinus, as is more often the case in *H. evax.* This variety manifests a considerable range in form, some of the shells coming very close to those of the Waldron area. The very close kinship of this species to *H. apriniformis* Hall is evident.

Dimensions of two individuals are: Length, 15 mm.; width, 16 mm.; thickness, 9 mm.; and length, 13 mm.; width, 13 mm.; thickness, 8.3 mm.

Occurrence.—McKENZIE FORMATION. Throughout the Maryland area.

Collection.—Maryland Geological Survey.

Genus TREMATOSPIRA Hall

TREMATOSPIRA CAMURA Hall

Plate XXIV, Figs. 26-30

Atrypa camura Hall, 1852, Pal. N. Y., vol. ii, p. 275, pl. lvi, fig. 3.
Trematospira camura Hall, 1859, Pal. N. Y., vol. iii, p. 212, pl. xxviiiA, fig. 1.
Rhynchonella camura Billings, 1863, Geol. Canada, p. 315, fig. 322.
Trematospira camura Lesley, 1889, Geol. Survey Penn., Rept. P4, p. 884, figs.
Trematospira camura Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, p. 136, pl. xlix, figs. 2-4.
Trematospira camura Grabau, 1901, Bull. N. Y. State Mus., 45, p. 201, fig. 122.
Trematospira camura Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 201, fig. 122.
Trematospira camura Grabau and Shimer, 1907, N. A. Index Fossils, vol. i, p. 345, fig. 443.

Description.—"Subrhomboidal, semioval or depressed globose (varying in form by age) valves nearly equally convex, or the ventral is a little deeper than the dorsal; beak of the dorsal valve small, acute, projecting

[1] Twenty-eighth Rept. New York State Mus. Nat Hist. p. 160.

beyond the cardinal line of the ventral valve, and slightly incurved, surface marked by simple angular plications on each side and by one or two smaller ones in the center; plications crossed by fine, thread-like, concentric striæ, with a few strong imbricating lamellæ below the center; an oval aperture or foramen below the beak. The number of plications is usually about five or six on each side of the smaller one in the center and there is scarcely any increase of the number in older shells."—Hall, 1852.

Most of the Maryland forms have five large and from one to two smaller plications on each side of the central smaller plication. This corresponds to the illustrations of this species from New York.

Two pedicle valves measure, respectively: Length, 8 mm.; width, 10 mm.; and length, 8.5 mm.; width, 11 mm.

Occurrence.—MCKENZIE FORMATION. Flintstone, Maryland. ROCHESTER FORMATION. East of Tonoloway, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

Family MERISTELLIDAE

Subfamily HINDELLINAE

Genus HINDELLA Davidson

Subgenus GREENFIELDIA Grabau

HINDELLA (?) (GREENFIELDIA) CONGREGATA Swartz n. sp.

Plate XXV, Figs. 10-22

Description.—Shell varying from subquadrangular or subpentagonal to subovate, usually transverse, biconvex; hinge-line short; greatest width in typical shells slightly back of center of shell, in others it may be in front of center; posterior margin straight or slightly concave from beak to point of greatest width, thence its margin curves regularly towards front which is dorsally arcuate and frequently emarginate. Ventral valve more convex than dorsal, its point of maximum convexity being about one-third its length from beak; its surface curving regularly from beak to anterior margin, concave between beak and hinge-line, its beak slightly incurved over a triangular foramen. Dorsal valve bearing a small incurved beak, its surface convex towards front, concave towards hinge-line. Surface of valves smooth, or marked by fine concentric striæ or growth lines. Ventral valve bears a sinus which is faint near umbo, becoming broader and distinct anteriorly. Dorsal valve bears a low median fold which is distinct in older shells. The center of the fold is marked in many shells by a narrow sinus which makes the front emarginate.

The interior of the ventral valve bears two thin dental laminæ between which the shell is slightly thickened. The hinge plate of the dorsal valve is depressed in center to form a small spondylium, on each side of which is a shallow dental socket. No well defined median septum appears to exist in the dorsal valve, although some specimens appear to bear a low raised median line. Brachidia form spirals of about seven coils united by a jugum. The details of the interior were not seen.

Dimensions of typical specimen: Length, 10 mm.; width, 7.1 mm.

The generic position of these shells is uncertain. They do not show the median septum characteristic of the genus *Whitfieldella,* nor are they clearly referable to *Hindella.* A subgenus *Greenfieldia* was erected by Grabau to receive species of this type. Maryland specimens were referred by Grabau to his species *Meristospira michiganensis,*[1] but appear to lack the features of that form.

These shells are subject to so wide a variation in size, outline, and gibbosity as to suggest that individuals of more than one species may be included in the material described. All are, however, connected by so many transitional forms that the author has not been able to separate them successfully.

This species closely approaches *H. whitfieldi* Grabau of Greenfield, Ohio, from which it is distinguished chiefly by slight differences of proportion. The associated faunas in Ohio are, however, quite distinct from those in Maryland.

This is the most abundant species in the Tonoloway, occurring in great profusion near the middle of the formation wherever that horizon is exposed.

[1] Grabau, A. W., Monroe Formation, Mich. Geol. and Biol. Survey, 1910, p. 231.

Occurrence.—TONOLOWAY FORMATION. Throughout the Maryland area. WILLS CREEK FORMATION. Pinto ?, Flintstone Creek ?.

Collection.—Maryland Geological Survey.

HINDELLA (?) (GREENFIELDIA) CONGREGATA var. INTERMEDIA Swartz n. var.

Plate XXV, Figs. 23-28

Description.—This variety differs from the typical form in being smaller, more gibbous, sinus inconspicuous.

Length, 9 mm.; width, 7 mm.; thickness, 5 mm.

Occurrence.—TONOLOWAY FORMATION. Quarry west of Hancock, Maryland; Keyser-Heddenville Road and Quarry of Standard Lime and Stone Company, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

HINDELLA (?) (GREENFIELDIA) CONGREGATA var. PUSILLA Swartz n. var.

Plate XXVI, Figs. 1-5

Description.—This variety differs from both the typical form and the variety *intermedia* in its very small size and indistinct sinus. The shells commonly occur associated in considerable numbers suggesting a depauperated fauna.

Length, 7 mm.; width, 5 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, Mullen's Quarry, Cumberland, National Road on Martin Mountain, Maryland; Keyser-Heddenville Road, Keyser, Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

HINDELLA (?) (GREENFIELDIA) cf. ROTUNDATA (Whitfield)

Plate XXVI, Figs. 6-8

Nucleospira rotundata Whitfield, 1882, Ann. N. Y. Acad. Sci., vol. ii, p. 194, pl. v, figs. 11-14.

Nucleospira rotundata Whitfield, 1893, Ohio Geol. Survey, vol. vii, p. 413, pl. i, figs. 11-14.

Nucleospira rotundata Sherzer, 1900, Mich. Geol. Survey, vol. vii, p. 223, pl. xvii, figs. 11-14.

Hindella? (Greenfieldia?) rotundata Grabau, 1910, Mich. Geol. Survey, Monroe Formation, p. 150, pl. xxx, figs. 11-14.

Description.—A single specimen has been observed in the Tonoloway of Maryland which is described as follows: Shell small, ovate, in outline, length and width subequal, subglobose, valves equally convex, front emarginate. Ventral valve with beak closely incurved over opposite valve; point of greatest convexity near center, curving rapidly towards hinge-line, sinus shallow, extending from center to front possibly due, in part, to crushing; hinge-line very short. Dorsal valve having beak incurved beneath that of ventral valve, point of greatest convexity back of center, surface curving rapidly towards post-lateral slopes, hinge-line very short, having a narrow, shallow median sinus which begins in front of center and extends to front, where it is more distinct. Surface smooth save in front, where it is marked by concentric growth lines which become stronger towards anterior margin.

The single shell observed resembles Whitfield's *H. rotundata* with which it may be compared. It is, however, much smaller. More material is required for its assured identification.

Length, 7 mm.; width, 7 mm.; thickness, 5 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto.

Collection.—Maryland Geological Survey.

Subfamily MERISTELLINAE

Genus MERISTINA Hall

MERISTINA cf. MARIA Hall

Plate XXVI, Figs. 9-12

Meristella maria Hall, 1863, Trans. Alb. Institute, vol. iv, p. 212, Abstract, p. 18.

Meristina maria Hall, 1867, Pal. N. Y., vol. iv, p. 299.

Meristina maria Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., Mus. edit., p. 159, pl. xxv, figs. 8-12.

Meristina maria Hall, 1881, 11th Ann. Rept. Ind. Geol. & Nat. Hist., p. 299, pl. xxv, figs. 8-12.

Description.—" Shell of medium or large size, ventricose, broadly ovate or subquadrangular. Ventral valve gibbous above, with a subangular ridge extending from beak to near the middle, where it becomes flattened, sinuate and bent abruptly upward in a prolonged linguiform extension, beak obtuse, closely incurved over the opposite valve, cardinal slope angular and the cardinal border inflected. Dorsal valve gibbous, strongly arcuate transversely, prominently subangular along the middle and in the lower part presenting a broad, undefined fold, deeply emarginate in front for the reception of the extension of the opposite valve; beak obtuse, strongly incurved. Surface marked by strong concentric lines of growth. Interior of the ventral valve marked by two strong diverging dental lamellæ which extend to near the middle, limiting a deep triangular muscular cavity."—Hall, 1881.

The forms studied are closely related if not identical with *Meristina maria.*

Two pedicle valves measure, respectively: Length, 20 mm.; width, 20 mm.; and length, 23 mm.; width, 22 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

MERISTINA GLOBOSA Prouty n. sp.

Plate XXVI, Figs. 27-30

Description.—Shell subpentagonal, subglobose; valves subequal; pedicle valve bearing a broad shallow sinus which becomes narrow and somewhat angular posteriorly, extending to near the beak; brachial valve bearing a broad low fold toward front; beaks broad, closely incurved. Surface marked by rather fine concentric lines, about four to the millimeter, which are closer locally toward the front of the shell; the concentric lines are crossed by inconspicuous radiating lines, numbering about five to the millimeter.

Length, 8.5 mm.; width, 9 mm.; thickness, 7 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland. ROSE HILL FORMATION. Pinto, Flintstone.

Collection.—Maryland Geological Survey.

MERISTINA sp.

Plate XXVI, Figs. 13, 14

Description.—Shell ovate, convex, posterior margins nearly straight, anterior margin rounded, beaks acutely pointed, incurved. Pedicle valve bearing a slight sinus. Exterior of valves smooth. Interior of pedicle valve bears two strong septa which extend nearly to front margin, enclosing a narrow $\wedge$-shaped area between them. Two short septa are also present exterior to them. Internal casts exhibit distinct radiating vascular markings.

Length: 13.5 mm.; width, 11.5 mm.

Occurrence.—MCKENZIE FORMATION. Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Genus WHITFIELDELLA Hall and Clarke

WHITFIELDELLA MARYLANDICA Prouty n. sp.

PLATE XXVI, Figs. 15-24

Description.—Valves about equally convex; length and breadth subequal; greatest width midway between beak and front margin or slightly nearer front margin; gibbous near beak and becoming thinner toward front; greatest thickness about one-third way from point of beak to front margin; surface marked by rather fine growth lines which are usually more numerous and distinct near the anterior margin. The pedicle valve has a rather shallow sinus which is usually limited to the front half of the shell, while the brachial valve bears a correspondingly low fold. The beak of the pedicle valve is rather sharp and is incurved over that of the brachial valve.

This species much resembles the smaller form of *W. intermedia* (Hall) of the Clinton and Niagaran of New York, and is also closely related to *W. nucleolata* (Hall) of the Coralline limestone of New York. The form is rather variable. Some specimens resemble *W. subovata.* The two species may prove to be identical.

This species occurs in great profusion in a narrow zone at the top of the Rochester formation at all localities where its horizon is exposed.

Three shells measure, respectively: Length, 11 mm.; width, 11.5 mm.; thickness, 7.5 mm.; length, 10 mm.; width, 11 mm.; thickness, 5.5 mm.; length, 10 mm.; width, 10 mm.; thickness, 7 mm.

Occurrence.—McKENZIE FORMATION. Pinto, Rose Hill, Cumberland. ROCHESTER FORMATION. Abundant in all the exposures.

Collection.—Maryland Geological Survey.

WHITFIELDELLA SUBOVATA Prouty n. sp.

Plate XXVII, Figs. 1-5

Description.—Elongate-cylindrical; width and thickness nearly equal; valves about equally convex, greatest width and greatest thickness about half-way between point of beak and the front; brachial valve with low, broad mesial fold; pedicle valve with shallow mesial depression extending from a little in front of the beak to front border; surface marked by rather fine concentric lines; beak of pedicle valve small and well incurved over that of the brachial valve.

This form occurs sparingly with *W. marylandica,* which it resembles and from which it differs in being proportionately longer and thicker and having a slightly better marked mesial sinus in the pedicle valve. It suggests somewhat a dwarf form of *W. cylindrica.*

Length, 11 mm.; width, 8 mm.; thickness, 7.5 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

Family COELOSPIRIDAE

Genus COELOSPIRA Hall

COELOSPIRA HEMISPHERICA (Sowerby)

Plate XXVI, Figs. 25, 26

Atrypa hemispherica Sowerby, 1839, Murchison's Silurian System, p. 637, pl. xx, fig. 7.

Atrypa hemispherica ? Hall, 1843, Geol. N. Y., Rept. 4th Dist., p. 73, fig. 4.

Atrypa hemispherica, Hall, 1852, Pal. N. Y., vol. ii, p. 74, pl. xxiii, fig. 10.
Atrypa hemispherica Billings, 1863, Geol. Canada, p. 318, fig. 337.
Leptocoelia hemispherica Hall, 1859, 12th Rept. N. Y. State Cab. Nat. Hist., p. 77.
Atrypa flabella Shaler, 1865, Bull. Mus. Comp. Zool., vol. iv, p. 68.
Leptocoelia hemispherica Nettleroth, 1889, Kentucky Fossil Shells, Mem. Ky. Geol. Survey, p. 152, pl. xxxii, figs. 21-23, 36-38.
Leptocoelia hemispherica Foerste, 1890, Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 325, pl. vi, figs. 18, 19.
Coelospira ? hemispherica Hall and Clarke, 1893, Pal. N. Y., vol. viii, pt. 2, p. 136, pl. lxxxii, figs. 1-4 (? pl. lii, fig. 16).
Anoplotheca hemispherica Schuchert, 1897, Bull. U. S. Geol. Survey, No. 87, p. 145.
Anoplotheca hemispherica Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 205, fig. 132.
Anoplotheca hemispherica Grabau and Shimer, 1907, N. A. Index Fossils, vol. i, p. 350, fig. 455.

Description.—" Shell hemispherical or semiorbicular, plicated, ventral valve flat, nearly orbicular, dorsal valve convex; hinge-line extended and nearly straight, surface marked by from eight to twelve rounded or subangular, simple plications, which are crossed by strong undulating and imbricating lamellæ.

" The species is easily recognized by its convex, nearly orbicular dorsal and flat ventral valves, differing widely from every species in the group except *Anoplotheca planoconvexa* (Hall), from which it differs in the smaller number and simpler character of the plications."—Hall, 1852.

A pedicle valve is 12.6 mm. long, 13 mm. wide. A ventral valve is 10 mm. long, 12.6 mm. wide.

Occurrence.—ROSE HILL FORMATION. In the middle beds throughout the Maryland area.

Collections.—Maryland Geological Survey, U. S. National Museum.

COELOSPIRA SULCATA Prouty n. sp.

Plate XXVII, Figs. 6-8

Description.—Shell semicircular in outline, slightly broader than long, pedicle valve convex, convexity equals about one-fourth diameter of shell, greatest convexity at about center, thus giving a domed appearance, mesial fold rather low and narrow toward beak, gradually widening and flattening toward front. On either side of mesial fold there are three to four low, rounded plications, which are crossed by a few broad, somewhat wavy, concentric lines; beak depressed to margin of shell. Exfoliated forms show a narrow groove in center of mesial fold towards beak, which begins a little in front of the beak and reaches nearly to the middle of the shell. Brachial valve almost flat with a sharply defined narrow sinus extending from beak to front margin. Sometime one or two faint plications are visible on either side of the sinus which are crossed by rather low, faint concentric lines.

This shell resembles in some ways *C. hemispherica* and *C. planoconvexa*. From the former it differs markedly in shape; from the latter in the character of its plications.

Length, 8 mm.; width, 8 mm.

Occurrence.—ROCHESTER FORMATION. Flintstone, Maryland; Great Cacapon, West Virginia. ROSE HILL FORMATION. Throughout the Maryland area in the upper beds of the formation.

Collection.—Maryland Geological Survey.

MOLLUSCA

CLASS PELECYPODA

Order PRIONODESMACEA

Family GRAMMYSIIDAE

Genus CUNEAMYA Hall and Whitfield

CUNEAMYA ULRICHI Prouty n. sp.

Plate XXVII, Figs. 9, 10

Description.—Shell flat, subglobose to heart-shaped, the anterior end much higher than posterior, with broad, high, inflated, nearly terminal and strongly incurved beaks, which have a breadth at the hinge-line greater than one-half the length of the shell; hinge-line straight, with both lunule and escutcheon short; cardinal and basal margins converging slightly posteriorly; anterior margin slightly transverse, broadly rounded above, more sharply rounded toward base; basal margin nearly straight to slightly concave in center, gently rounding toward posterior margin, which is more acutely terminated than anterior margin; posterior umbonal slope prominent and angular above, gradually rounding out as it extends backward, reaching to about the middle of the posterior margin; anterior umbonal slope more uniformly rounded and extending to lower anterior margin. A shallow mesial sulcus is sometimes faintly developed. Casts show concentric growth lines slightly more prominent toward the anterior of shell.

Specimens observed are all casts and show considerable variation in regard to the character of the posterior margin.

The dimensions of two shells are: Length of both 15 mm.; height, 10 mm. and 11 mm.; thickness, 11 mm. and 12 mm.

Occurrence.—McKENZIE FORMATION. Cedar Cliff, Flintstone.

Collection.—Maryland Geological Survey.

Genus GRAMMYSIA Verneuil

GRAMMYSIA KIRKLANDI Prouty n. sp.

Plate XXVII, Fig. 12

Description.—Shell elongate-subelliptical, evenly convex; length twice height; cardinal margin straight, about two-thirds length of shell; anterior margin rounded; posterior margin obliquely truncate, produced ventrally; ventral margin broadly and evenly rounded throughout; umbones low, wide, rising slightly above hinge-line, distant about one-fifth length of shell from anterior margin. Internal cast bearing faint concentric lines and one or two low concentric undulations. Two shallow depressions extend obliquely backward from umbones toward ventral margin, vanishing about half-way to the margin.

Length, 37 mm.; height, 19 mm.

Occurrence.—ROSE HILL FORMATION. Six-mile House, Maryland; Devils Nose near Sir Johns Run, West Virginia.

Collection.—Maryland Geological Survey.

Superfamily NUCULACEA

Family CTENODONTIDAE

Genus CTENODONTA Salter

CTENODONTA SUBCIRCULARIS Prouty n. sp.

Plate XXVII, Fig. 11

Description.—Shell subcircular, rather small, nearly uniformly though not markedly convex, beak rather small, nearly straight and centrally situated; anterior dorsal margin rather sharply incurved to anterior umbonal slope; surface marked by from three to four rather fine, sharp growth-lines near the basal margin and one or two nearer the beak which seem to be stronger anteriorly; fine concentric lines are very faintly observed on the casts studied.

Species resembles *C. hamburgensis* Walcott, but differs in its more markedly circular outline, less convexity, and smaller beak.

Length, 10.3 mm.; height, 10.3 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

CTENODONTA SUBRENIFORMIS Prouty n. sp.

Plate XXVII, Figs. 13-15

Description.—Shell rather small, one and a half times as long as high, beaks prominently compressed and but little incurved, situated 2.5 mm. in the smallest specimen and 4.5 mm. in the largest specimen behind the anterior margin, which is nearly vertical and obtusely rounded. A moderately broad lunule extends about one-third way down front margin with rather high median-ridge which bears geniculate denticulations; basal margin slightly convex; passing backwards into an obliquely subtruncate posterior border, the upper extremity of which is more sharply rounded to meet the cardinal extremity; hinge-line more or less curved, denticulate throughout with about six or seven strongly interlocking teeth in center of shell posterior to umbos. Adductor scars strongly marked, the anterior pair bordering lower part of the lunule and reaching part way toward the beak. The posterior ones are more prominent and are located on the elevated cardinal extremity. The casts of the interior, the only forms observed, show one or two strong and two or three much weaker concentric folds, nearer the basal border than the beaks. Most of the forms show a short and shallow clavicle cutting the rather angular posterior umbonal slope just behind the beak and extending backwards and downwards for about one-fifth of the width of the shell.

The dimensions of an average specimen are: Length, 11.5 mm.; height, 8.3 mm.; thickness, 5.8 mm.

Occurrence.—McKENZIE FORMATION. Pinto, Cedar Cliff.

Collection.—Maryland Geological Survey.

CTENODONTA OVATA Prouty n. sp.

Plate XXVII, Fig. 18

Description.—Shell ovate-trigonal in outline, moderately convex, height about three-quarters length; dorsal margin very slightly convex, anterior end semicircular, posterior end rounding more abruptly into the dorsal and ventral margins; ventral margin smoothly and evenly arcuate; umbones acute, prominent, rising well above the dorsal margin, distant about one-third length of shell from anterior margin. Hinge weak, consisting of about 16 teeth. Surface marked by fine, closely spaced, concentric lines, every fourth to sixth line more prominent.

Length, 20 mm.; height, 15 mm.

Occurrence.—ROCHESTER FORMATION. Six-mile House.

Collection.—Maryland Geological Survey.

CTENODONTA WILLSI Prouty n. sp.

Plate XXVII, Figs. 16, 17

Description.—Shell nearly elliptical in outline, very slightly narrower at the anterior extremity; height one-half length; low convex. Dorsal and ventral margins subparallel; anterior margin broadly rounded, posterior margin obtusely and obscurely angulated at the juncture with the dorsal and ventral margins; umbones low, wide, situated at about the anterior third. Surface bearing two low diverging angulations, one of which passes obliquely backward and one obliquely forward from umbo, vanishing before reaching ventral margin; marked with weak, distant, concentric lines, which are more prominent posteriorly.

This species is similar to *Tellinomya elliptica* Hall of the upper gray sandstone of the Clinton of Herkimer County, New York, but differs in being slightly more elongate and having less equal extremities.

Length, 20 mm.; height, 10 mm.

Occurrence.—ROSE HILL FORMATION. About 60 feet below the lower "iron-ore" bed, Cumberland.

Collection.—Maryland Geological Survey.

Family LEDIDAE

Genus CLIDOPHORUS Hall

CLIDOPHORUS NITIDUS Prouty n. sp.

Plate XXVII, Figs. 19-21

Description.—Shell subelliptical to elongate trigonal, about two-thirds as high as long, moderately convex; beaks moderately strong, flattened, slightly elevated and incurved; dorsal line convex, obliquely truncated posteriorly; anterior angle less acute and more uniformly rounded than posterior angle, which is made re-entrant by the presence of a rather broad and strong posterior umbonal sulcus which continues, diminishing in depth and width, to the beak.

The fold on the posterior side of this sulcus is a prominent ridge running to beak and forming a somewhat angular posterior margin to the umbo. Backward from this ridge the shell descends rather rapidly to the margin. Casts of the interior show a narrow, slightly curved, clavicular impression just in front of the beak, extending about half-way to the antero-basal margin. First undulating growth lines noticeable on mid-lateral surface of many of the casts and fine radiating lines in posterior and anterior portions.

Length, 11 mm.; height, 7 mm.; thickness, 2.5 mm.

Occurrence.—McKENZIE FORMATION. Pinto, Cedar Cliff, Six-mile House, Rabble Run, Maryland; Grasshopper Run, West Virginia. ROCHESTER FORMATION. East of Tonoloway, Maryland.

Collection.—Maryland Geological Survey.

CLIDOPHORUS SUBOBLONGATUS Prouty n. sp.

Plate XXVII, Fig. 22

Description.—Shell elongate, nearly three times as long as high; height about equal for approximately two-thirds the length of the shell; umbo well toward the front; front margin semitruncate, truncation beginning at the beak and making an obtuse angle of about 114° with the upper margin and a much sharper angle with the lower margin; the furrow is extended from the front of the beak downward and backward making an angle of about 75° with the upper margin; the posterior margin has a much flatter curve on the lower than on the upper side and is thus roughly parallel with the anterior margin; the upper margin is but slightly curved throughout its length.

This species resembles *C. oblongus* of the Hamilton, but differs in the less even rounding of its posterior margin and in the backward trend of the furrow.

Length, 14 mm.; height, 5 mm.

Occurrence.—ROSE HILL FORMATION. Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

CLIDOPHORUS sp.

Plate XXVII, Fig. 23

Description.—Shell nearly elliptical in outline, convex; length twice height; dorsal margin convex, only slightly less so than the ventral; shell evenly rounded anteriorly, posterior end not observed; beaks low; distant about one-third length from anterior margin. Internal cast bears a furrow which extends from the beak about half-way toward antero-ventral margin, slightly curved, with the concave side anterior. Surface of cast smooth.

Length, 19 mm.; height, 11 mm.

Occurrence.—McKENZIE FORMATION. Pinto.

Collection.—Maryland Geological Survey.

Superfamily PTERIACEA

Family PTERINEIDAE

Genus PTERINEA Goldfuss

PTERINEA EMACERATA (Conrad)

Plate XXVII, Figs. 25, 26

Avicula emacerata Conrad, 1842, Jour. Acad. Nat. Sci., vol. viii, p. 241, pl. xii, fig. 15.

Avicula emacerata Hall, 1843, Rept. 4th Dist., N. Y. Geol., p. 109, and figs. 4, 4a, p. 108.

Avicula emacerata Hall, 1852, Pal. N. Y., vol. ii, pp. 83, 282, pl. xxvii, figs. 1a, b; pl. lix, figs. 1a-e.

Pterinea emacerata Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 207, fig. 135.

Pterinea emacerata Weller, 1903, N. J. Geol. Survey, Rept. on Paleont., vol. iii, p. 242, pl. xxii, fig. 4.

Description.—"Much compressed; lower valve plane-convex, wider than high, with numerous fine, equal radii; summit of umbo a little above the cardinal line; posterior wing acutely angular at the extremity, which is nearly on a line with the rounded posterior end of the valve; anterior wing very short, triangular."—Conrad, 1842.

Left valve convex, marked by strong radiating striæ which are decussated by less conspicuous concentric striæ; posterior margin of wing deeply arcuate. This species is recognized by its left valve which has strong rays regularly cancellated by concentric striæ.

Two shells measure, respectively: Length, 30 mm.; height, 21 mm.; and length, 40 mm.; height, 30 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Sixmile House, Maryland; Great Cacapon, West Virginia. ROSE HILL FORMATION. Cresaptown, a few feet below the lower ferruginous sandstone.

Collection.—Maryland Geological Survey.

PTERINEA FLINTSTONENSIS Prouty n. sp.

Plate XXVIII, Figs. 16-19

Description.—Length about one and one-half times height; angle between hinge-line and posterior margin of shell about 40°; posterior wing slightly more than half the length of the shell; anterior wing (not entirely preserved in any of the specimens studied) extends forward from the front margin of the shell about 2 mm. in the small specimens and about 4 mm. in the large specimens; surface of left valves (the only ones observed) marked by rather broad, imbricating, irregularly concentric lines, which at their border are turned on edge, especially where they cross the radiating striæ. At about 10 mm. distant from the beak the concentric lines number from about eight to nine in a space of 5 mm. Surface is also ornamented by radiating lines which are about equal in width to the spaces between. Toward the border of the shell these lines are often deflected and wavy. At a distance of 10 mm. from the beak the radiating lines number about 16 in a distance of 5 mm.

This shell rather closely resembles *P. brisa* Hall, but differs mainly in the angle between the posterior border and the hinge-line, the character of the posterior wing and to some extent in the character of the surface ornamentation.

Length, 30 mm.; height, 20 mm.; convexity of left valve, 8 mm. to 9 mm.

Occurrence.—McKENZIE FORMATION. Throughout the Maryland area.

Collection.—Maryland Geological Survey.

PTERINEA ELONGATA Prouty n. sp.

Plate XXVII, Fig. 24

Description.—Shell subrhomboidal, body subovate, oblique at an angle of about 60° with hinge-line; height about five-eighths the length; bearing a small ear anteriorly and a broad wing posteriorly. A very shallow sinus is present near ventral margin which is situated immediately below beak. Cardinal margin straight, shorter than shell; anterior ear smaller, triangular, not sharply separated from body; anterior margin curving obliquely backward; ventral margin slightly curved; posterior margin curving sharply at junction with ventral margin; wing directed obliquely forward. Umbones prominent, projecting above hinge-line, situated one-fourth length of shell from anterior end. Posterior wing triangular, concave, not sharply defined from shell. Surface bearing numerous concentric lines between which are fainter concentric striæ which become fainter towards beak. The wing appears to bear a few indistinct radiating striæ.

The above description is from a well-preserved cast of left valve. Its shape suggests somewhat that of the genus *Leptodesma*. The character of the ornamentation and its general shape shows it to be a new species.

Length, 22 mm.; height, 13.5 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill.

Collection.—Maryland Geological Survey.

PTERINEA CANCELLATA Prouty n. sp.

Plate XXVIII, Figs. 20, 21

Description.—Left valve subrhomboidal, bearing anterior and posterior wings; body strongly convex, post-umbonal slope making an angle of about 36° with hinge-line. Hinge-line straight; umbones large, projecting distinctly above hinge-line. Anterior wing small, separated by a shallow sulcus from body, its dorsal margin oblique, sharply rounded anteriorly; anterior margin of body curved, directed obliquely backward, curving gradually into ventral margin; ventral margin broadly and regularly curved; posterior margin of body curving much more abruptly; posterior wing large, triangular, concave, its cardinal margin straight, but little shorter than shell, its posterior edge concave, post-cardinal angle acute.

The surface is ornamented by strong radiating concentric striæ; the main radiating striæ being interspersed by one or two small, yet well defined radiating lines; chief concentric striæ slightly finer than larger radiating ones and interspersed by four or five fine striæ. This species closely resembles in its surface ornamentation *P. emacerata* from which it differs, however, in being more convex, less fully rounded on the anterior margin and also narrower anteriorly. It also resembles *Actinopteria reticulata* of the Decker Ferry formation of New Jersey, but its surface markings show it to be entirely distinct from that species.

Length, 28 mm.; height, 24 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill.

Collection.—Maryland Geological Survey.

Family PTERIIDAE

Genus ACTINOPTERIA Hall

ACTINOPTERIA ? sp.

Plate XXVIII, Figs, 22-25

Description.—Shell subtriangular, height two-thirds length, attenuate anteriorly, very convex, point of greatest convexity near middle. Surface ornamented by fine undulating radiating striæ which are crossed occasionally by concentric growth lines. A fragment of a somewhat larger valve has striæ alternating slightly in strength.

This species is represented by a few valves which are too imperfect to permit confident determination. It appears to be a new species.

Length, 10 mm.; height, 7 mm.

Occurrence.—WILLS CREEK FORMATION. Pinto, Cement Mill on Wills Creek, Cumberland.

Collection.—Maryland Geological Survey.

Genus LIOPTERIA Hall

LIOPTERIA SUBPLANA (Hall)

Plate XXVIII, Figs. 1-3

Avicula subplanus Hall, 1852, Pal. N. Y., vol. ii, p. 283, pl. lix, figs. 3a-c.
Avicula subplana Rogers, 1858, Geol. Penn., vol. ii, pt. 2, p. 823, fig. 628.
Pterinea subplana Billings, 1866, Cat. Sil. Foss. Anticosti, Geol. Survey Canada, p. 52 (gen. 19).
Avicula subplana Lesley, 1889, Geol. Survey Penn., Rept. P4, p. 70, fig.
Liopteria subplana Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 208, fig. 136.

Liopteria subplana Grabau, 1901, Bull. N. Y. State Mus., No. xlv, p. 208, fig. 130.

Pteronites subplana Weller, 1903, Geol. Survey N. J., Pal., vol. iii, p. 243, pl. xxii, fig. 1.

Leiopteria subplana Grabau and Shimer, 1909, N. A. Index Fossils, vol. i, p. 424, fig. 554.

Description.—" Extremely depressed, left valve subrhomboidal, the height equal to about three-fourths of the length, elevated toward the umbo, and nearly flat toward the center of the valve, posterior wing scarcely distinct from the body of the shell, truncated at its extremity; cardinal line equal to or less than the length of the shell; surface marked by concentric striæ which are scarcely undulated on the wing; right valve smaller, nearly flat, with the wing more extended, surface similarly marked; anterior wing on both valves scarcely conspicuous."—Hall, 1852.

All the forms observed are rather imperfect, but as the left valve of one is preserved identification is possible.

Two shells measure, respectively: Length, 30 mm.; height, 20 mm.; and length, 21 mm.; height, 14 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

LIOPTERIA ? PENNSYLVANICA Swartz n. sp.

Plate XXVII, Fig. 27

Description.—Shell subrhomboidal, body oblique, ovate, height about equal to length. Anterior ear small, not well defined from body; anterior margin oblique, nearly straight; ventral and posterior margins semicircular; posterior wing not observed. Beak small, acute; point of greatest convexity a short distance back of the beak; body elevated along a line parallel to anterior margin, sloping rapidly towards anterior margin, more gradually towards hinge, still more slowly to post-inferior margin. Surface smooth, with faint concentric growth lines.

The body of this shell resembles that of species of the genera *Leptodesma* and *Liopteria.* The posterior wing is unknown, rendering generic identification insecure.

Length, 25 mm.; height, 24 mm.

Occurrence.—TONOLOWAY FORMATION. Quarry west of Haneoek, Maryland; Grasshopper Run, West Virginia; Warren Point, Pennsylvania.

Collection.—Maryland Geological Survey.

LIOPTERIA sp.

Plate XXVIII, Fig. 26

Description.—Shell subrhomboidal, length and height nearly equal; eonvex, bearing anterior and posterior wings; body broadly ovate, post-umbonal slope making an angle of about 40° with hinge-linc; umbo large, elevated above hinge-line. Anterior wing not observed; anterior margin convex, rounding gradually into ventral margin; ventral margin broadly eonvex; posterior margin of body curving more abruptly to postcrior wing; posterior wing large, triangular, concave, its dorsal margin straight and longer than shell, its posterior margin concave. Surface bearing numerous rather irregular imbricating growth lamellæ.

Length, 38 mm.; height, 35 mm.

Occurrence.—McKENZIE FORMATION. Grasshopper Run, West Virginia.

Collection.—Maryland Geologieal Survey.

Superfamily MYTILACEA

Family MODIOLOPIDAE

Genus MODIOLOPSIS Hall

MODIOLOPSIS GREGARIUS Swartz n. sp.

Plate XXVIII, Figs. 4-8

Description.—Shell small, subovate; height about three-fifths length; ventral margin slightly eonvex, eurving abruptly at post-inferior angle to join posterior margin, curving more gently at anterior extremity; posterior margin slightly rounded, nearly truncate in some speeimens, obliquc; cardinal margin nearly parallel to ventral margin, slightly eurved; anterior end short, constricted, its upper margin slightly concave; greatest length along a line drawn nearly midway between top and bottom of valve. Beaks small, situated about one-quarter length of shell from anterior end, a rounded post-umbonal ridge extending from them to posterior angle. Valves convex; surface between post-umbonal ridge and cardinal margin becoming nearly flat posteriorly, concentrically striated by fine lines. Interior unknown.

This species resembles *M. dubius* of the Manlius of New York, but is a larger shell, proportionally higher, its ventral and cardinal margins less distinctly parallel. It occurs in large numbers in some beds, hence its specific name.

Its proportions vary considerably. Length, 17 mm.; height, 10 mm.; thickness, 4 mm. in a typical individual.

Occurrence.—TONOLOWAY FORMATION. Mullen's Quarry, Cumberland, National Road on Martin Mountain, Quarry west of Hancock, Maryland; Keyser-Heddenville Road, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

MODIOLOPSIS CUMBERLANDICUS Prouty n. sp.

Plate XXVIII, Fig. 9

Description.—Shell subrhomboidal, height equal to about one-half the length; rounded anteriorly and truncated behind; dorsal and ventral margins nearly parallel, posterior margin long, slightly convex, rounding abruptly above and below into the dorsal and ventral margins, respectively, anterior margin hardly differentiated from the dorsal and ventral, rounding smoothly above and below; beaks low, acute, rising above the dorsal margin, situated at about the anterior third. Surface regularly marked by equidistant concentric lines, which are about .5 mm. apart on posterior portion of shell.

Length, 10 mm.; height, 6 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland, Flintstone.

Collection.—Maryland Geological Survey.

MODIOLOPSIS cf. SUBCARINATUS Hall

Plate XXVIII, Figs. 10, 11

Description.—"Shell elongate, somewhat rhomboidal-oval; young specimens with an obtuse carina along the posterior umbonal slope, reaching to the posterior basal margin; anterior extremity rounded; posterior extremity obliquely truncated or rounded; base slightly arcuate; surface marked by strong concentric folds, which are scarcely conspicuous on the posterior part of the shell. In old shells the carina and concentric folds become obsolete."—Hall, 1852.[1]

Two shells measure, respectively: Length, 19 mm.; height, 8.7 mm.; and length, 14 mm.; height, 7 mm.

Occurrence.—ROSE HILL FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

MODIOLOPSIS LEIGHTONI Williams ?

Plate XXVIII, Figs. 12, 13

Description.—"Shell transversely subovate; length a little more than twice the height; hinge-line nearly straight; posterior height slightly greater than anterior. Beak within the anterior third of hinge length, low, flattened, ovate, arching; the umbonal ridge strong, gradually flattening out towards postero-ventral angle. Middle of shell flattened, slightly depressed from over the beak to the front. Surface covered by irregular lines of growth."—Williams, 1913.[2]

Williams described this species from the Eastport, Maine, quadrangle. While the Maryland basin seems to be distinct from that at Eastport, the shells here described seem indistinguishable from Williams' species. Further collections may show that they are distinct. They differ from

[1] *Modiolopsis subcarinatus* Hall, 1852, Pal. N. Y., vol. ii, p. 101, pl. xxx, figs. 3a-d, 4a.

[2] *Modiolopsis leightoni* Williams, 1913, Proc. U. S. Nat. Mus., vol. xlv, p. 346, pl. xxxi, figs. 7-10.

M. gregarius in their larger size, greater proportionate length, with a distinct sinus extending from near beak to basal margin center of shell.

Length, 23 mm.; height, 13 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, National Road on Martin Mountain, Quarry west of Hancock.

Collection.—Maryland Geological Survey.

Genus ORTHONOTA Conrad

ORTHONOTA ? MARYLANDICA Swartz n. sp.

Plate XXVIII, Figs. 14, 15

Description.—Shell small, elongate, height four-sevenths length. Anterior margin truncate, slightly oblique, rounding abruptly at junction with basal margin; basal margin slightly convex, curving gradually at posterior extremity; posterior margin convex, cardinal margin slightly curved. Beak small, situated very near anterior end. Shell bearing two angular ridges which extend backward from umbo; anterior ridge lower, reaching inferior margin a little back of middle of length of shell, posterior ridge stronger, about midway between anterior ridge and cardinal margin, dividing post-umbonal slope into two shallow sinuses which extend from beak to posterior margin. A broad and very shallow sinus extends from beak to middle of basal margin. Surface curving abruptly from anterior limit of sinus to anterior margin, bearing distinct concentric striæ. Interior unknown. This species is represented by a single valve.

Length, 10 mm.; height, 6 mm.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain, Quarry west of Hancock.

Collection.—Maryland Geological Survey.

CLASS GASTROPODA

SUBCLASS STREPTONEURA

Order ASPIDOBRANCHIA

Suborder DOCOGLOSSA

Family SINUITIDAE

Genus BUCANELLA Meek

BUCANELLA TRILOBATA (Conrad)

Plate XXIX, Figs. 1-6

Planorbis trilobatus Conrad, 1838, Ann. Rept. N. Y. Geol. Survey, p. 113.

Planorbis trilobatus Conrad, 1839, Ann. Rept. N. Y. Geol. Survey, p. 65.

Bellerophon trilobatus Hall, 1843, Rept. 4th Geol. Dist., p. 48, figs. 6, 7.

Bucania trilobatus Hall, 1852, Pal. N. Y., vol. ii, p. 13, pl. iv, figs. 5a, b; p. 93, pl. xxviii, fig. 9.

Bellerophon (Bucania) trilobata Foerste, 1893, Geol. Survey Ohio, Pal. vol. vii, p. 549, pl. xxvii, figs. 33a, b.

Bucaniella trilobata Clarke, 1900, Archivas Mus. Nac. Rio de Janeiro, vol. x, author's Eng. ed., p. 36.

Bucania trilobatus Grabau, 1901, N. Y. State Mus., Bull. 45, p. 213, fig. 144.

Description.—"Shell suborbicular, convoluted, three-lobed; volutions all visible, the last one greatly expanded; aperture much wider than long."—Hall, 1852.

Some of the specimens observed from Maryland seem better preserved than any heretofore described and show numerous fine longitudinal striæ which are crossed by finer and more closely set transverse striæ. The latter are better marked in the spaces between the longitudinal lines, to which they give, in some places, a nodose appearance.

The diameter of average shell is 13 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Sixmile House. ROSE HILL FORMATION. Cresaptown, Rose Hill.

Collection.—Maryland Geological Survey.

Family BUCANIIDAE

Genus OXYDISCUS Koken

OXYDISCUS COMPRESSUS Prouty n. sp.

Plate XXIX, Figs. 7, 8

Description.—Shell discoid; volutions compressed toward outer margin, their cross-section obtusely lanceolate; the outer volution embracing more than three-fourths of the inner; keel strong, sharp; umbilicus small, deep.

Diameter, 14 mm.

Occurrence.—ROCHESTER FORMATION. East of Tonoloway.

Collection.—Maryland Geological Survey.

Family BELLEROPHONTIDAE

Genus BELLEROPHON Montfort

BELLEROPHON MARYLANDICUM Prouty n. sp.

Plate XXIX, Figs. 9, 10

Description.—Shell subglobose, coiled in one plane; volutions closely embracing, increasing in diameter rapidly to near aperture where the shell expands abruptly; umbilicus small and shallow. Surface showing 10 to 12 faint revolving striations on either side of a slightly more conspicuous central carina; carina low, occupying the lateral space of two striations; two or three undulations or growth lines occur near the margin.

Diameter, 7 mm.

Occurrence.—ROCHESTER FORMATION. Flintstone.

Collection.—Maryland Geological Survey.

Order ASPIDOBRANCHIA

Suborder RHIPIDOGLOSSA

Family PLEUROTOMARIIDAE

Genus HORMATOMA Salter emend J. Donald

HORMATOMA ROWEI Swartz n. sp.

Plate XXIX, Figs. 11-15

Description.—Shell thin, elevated, turretiform; apical angle small; volutions about nine; whorls convex, peripheral band in center of whorl elevated, concave, bounded by two elevated raised carinæ; sutures deep; aperture subcircular; columella narrow in center, expanding towards sutures, causing it to be hourglass-shaped between sutures, perforate by a tubular opening which has a very small diameter in narrow parts of columella and expands towards sutures; umbilicus small, surface ornamented by fine striæ which curve backward in passing from suture to peripheral band; the width of the whorls about twice the distance between the sutures.

The elevation of the peripheral band resembles that observed in *Goniostrophia,* but the whorls are not angular as in that genus. In other respects it best accords with the genus *Hormatoma.*

This species was recognized as a new species by Rowe, but his description was never published. Its specific name is in honor of him. This is an abundant species at a few horizons in the Tonoloway.

Length, 25 mm.; diameter of last whorl, 8 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, Cumberland, Mullen's Quarry, National Road on Martin Mountain, Lanes Run, Maryland; Keyser-Heddenville Road, Keyser, West Virginia. WILLS CREEK FORMATION. Flintstone Creek, Round Top, Maryland.

Collection.—Maryland Geological Survey.

HORMATOMA ROWEI var. NANA Swartz n. var.

Plate XXIX, Figs. 16-20

Description.—Internal casts occur in the Tonoloway formation which resemble those of *H. rowei* save for their small size. Their association in large numbers and their prevailingly small size renders it probable that they are a distinct form. They present considerable variation in size and proportions. In the absence of knowledge of their sculpture they are referred to the species *H. rowei,* of which they may prove to be a depauperated variety.

An average individual has height, 12 mm.; diameter, 5 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto, Mullen's Quarry, Cumberland, National Road on Martin Mountain, Maryland; Keyser-Heddenville Road, Keyser, Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

HORMATOMA MARYLANDICA Prouty n. sp.

Plate XXIX, Figs. 21, 22

Description.—Shell turretiform, apical angle about 25°. Volutions usually 10 in number in full grown specimens, rounded, their greatest convexity a little in front of the center of the volution; sutures simple, moderately deep. Surface not observed.

This form approaches *H. subangulata* closely, but differs in having fewer and slightly broader whorls.

Length, 15 mm. to 33 mm.

Occurrence.—MCKENZIE FORMATION. Pinto, Cedar Cliff, Rose Hill, Six-mile House. ROCHESTER FORMATION. Rose Hill ?

Collection.—Maryland Geological Survey.

HORMATOMA HOPKINSI Prouty n. sp.

Plate XXIX, Figs. 23-25

Description.—Shell turretiform; volutions about seven, inflated, increasing rather rapidly in size; apical angle about 30°; upper volutions rounded, lower becoming obtusely angulated, the peripheral angle being slightly anterior in position and separating the basal, broadly convex surface from the apical, nearly flat face, the angle becoming increasingly sharp towards the aperture.

This species is characterized by the relatively great diameter of the volutions, their breadth being more than half their height, and by the peripheral angle which becomes increasingly sharp towards aperture.

Length, 15 mm. to 30 mm.

Occurrence.—MCKENZIE FORMATION. Pinto, Cedar Cliff, Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

Genus SOLENOSPIRA Ulrich

SOLENOSPIRA MINUTA Hall ?

Plate XXX, Figs. 1, 2

Murchisonia minuta Hall, 1859, Pal. N. Y., vol. iii, p. 298, pl. liv, fig. 17.
Solenospira minuta Grabau and Shimer, 1909, N. A. Index Fos., vol. i, p. 653.
Solenospira minuta Grabau and Sherzer, 1910, Mich. Geol. Survey, Monroe Formation, p. 175, pl. xvi, fig. 8.
Ectomaria minuta Bassler, 1915, U. S. Nat. Mus., Bull. 92, p. 472.

Description.—"Shell minute. Spire elongate, gradually attenuate; volutions about nine or more, rounded, bicarinate."—Hall, 1859.

"Shell minute with sharply augmented whorls, of which there are about nine in the space of 7 mm. Spire very slender, apical angle about 17°. The shoulder and body of the whorl are flat or slightly concave and the slit band margined by two elevated carinæ which give a prominent angularity to the whorl, the angulations being separated by marked concavities."—Grabau and Sherzer, 1910.

Internal casts of a minute shell found in the Tonoloway of Maryland are questionably referred to this species, which occurs in the Tonoloway in adjoining parts of Pennsylvania. Some of the casts are larger than the prevailing size of the species.

Length, 10 mm.; diameter, 3 mm.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Family TROCHONEMATIDAE

Genus HOLOPEA Hall

HOLOPEA (?) FLINTSTONENSIS Swartz n. sp.

Plate XXX, Figs. 3-5

Description.—Shell minute, subglobose to conical, spire low. Volutions about three in number, circular in cross-section save their upper inner surface which is concave where volutions are in contact. Umbilicus small. Surface of shell unknown.

This minute species is found only as internal casts, hence its description and generic position are not fully known. It occurs locally associated together in large numbers. A few individuals found with them are nearly double the normal size and may represent a different species.

Height, 3 mm.; diameter, 4 mm.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain, Maryland; Keyser-Heddenville Road, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Genus POLEUMITA Clarke and Ruedemann

POLEUMITA TRANSVERSA Prouty n. sp.

Plate XXIX, Figs. 27, 28

Description.—Shell pyramidal, having about three rounded volutions which rapidly increase in size and conceal about one-third of previous volution; last volution inflated. Surface ornamented by eight or nine strong spiral lines, which are crossed transversely by coarse and fine striæ. Spiral lines about $1\frac{1}{4}$ mm. apart, strong transverse sculpture about $\frac{7}{12}$ mm. apart, fine transverse lines $\frac{1}{8}$ mm. apart.

Length about 12 mm.; diameter about equal to length.

Occurrence.—ROCHESTER FORMATION. Rose Hill.

Collection.—Maryland Geological Survey.

POLEUMITA MCKENZICA Prouty n. sp.

Plate XXIX, Fig. 26

Description.—Shell pyramidal, apical angle about 90°; volutions three in number, rounded, increasing rapidly in size. The two casts seen show four equidistant, revolving striæ, the two median striæ distinct, the two outer faint; sutures deeply impressed. This form differs from *P. transversa* in its greater apical angle, less rapidly increasing size of volutions, and in its ornamentation.

Length, 10 mm.; diameter, 11 mm.

Occurrence.—MCKENZIE FORMATION. Cedar Cliff.

Collection.—Maryland Geological Survey.

Order CTENOBRANCHIATA

Suborder PLATYPODA

Superfamily GYMNOGLOSSA

Family PYRAMIDELLIDAE

Genus LOXONEMA Phillips

LOXONEMA (?) sp.

Plate XXX, Fig. 11

Description.—Shell elongate, turretiform. Volutions slightly concave between sutures, upper and inner surface concave where in contact, their height two-thirds their width; sutures shallow. Surface unknown.

A few internal casts have been observed which are distinguishable from those of *Hormatoma rowei* by the greater proportionate height of their volutions. They are too imperfect to permit confident identification.

Height, 30 mm.; diameter, 8 mm.

Occurrence.—TONOLOWAY FORMATION. Pinto.

Collection.—Maryland Geological Survey.

Superfamily TAENIOGLOSSA

Family CAPULIDAE

Genus ORTHONYCHIA Hall

ORTHONYCHIA CLARKI Prouty n. sp.

Plate XXX, Fig. 6

Description.—Small, curved, conical, shaped like a claw, apical angle about 19°; expanding uniformly and gradually; curvature slight near aperture, increasing towards apex; aperture subelliptical, its margin not sinuate. Surface marked by broad longitudinal undulations which become markedly angular toward the apex; bearing transverse lines which are rather uniformly and closely set, about four occurring in a space of 1 mm. Internal cast showing an occasional more deeply impressed growth line.

Length, 14 mm.; anterior-posterior diameter of aperture, 4.5 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill.

Collection.—Maryland Geological Survey.

Genus PLATYCERAS Conrad

PLATYCERAS PAUCISPIRALE Prouty n. sp.

Plate XXX, Figs. 7, 8

Description.—Shell conical, somewhat curved, expanding slowly, apical angle about 28°; slightly coiled at extreme end; cross-section elliptical to irregular. Surface of cast bears longitudinal undulations and is marked by transverse, more or less wavy growth lines; margin of aperture sinuous. This species resembles *P. niagarensis,* but has smaller apical angle and is slightly less coiled.

Length, 12 mm. to 18 mm.; diameter, 8 mm. to 9 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

PLATYCERAS NIAGARENSIS (Hall)

Plate XXX, Figs. 9, 10

Acroculia niagarensis Hall, 1852, Pal. N. Y., vol. ii, p. 288, pl. lx, fig. 3.
Acroculia niagarensis Roemer, 1860, Sil. Fauna West Tennessee, p. 76, pl. v, fig. 16.
Platyceras niagarensis Hall, 1868, 20th Rept. N. Y. State Cab. Nat. Hist., p. 341; rev. ed., 1870, p. 390.
Platyceras niagarensis Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. i, p. 211, fig. 139.
Platyceras niagarensis Grabau, 1901, Bull. N. Y. State Mus., No. 45, fig. 139.
Platyceras niagarensis Grabau, 1902, Amer. Nat., vol. xxxvi, p. 939.
Platyceras niagarensis Grabau and Shimer, 1909, N. A. Index Fos., vol. i, p. 680, fig. 954.

Description.—" Apex involute, scarcely forming a volution, gradually expanding below with two or three longitudinal folds or undulations, transversely striated; striæ undulating across the elevations and depressions of the surface."—Hall, 1852.

There seems to be some variation in the closeness of the involution in this species. The spiral angle, however, remains constant.

Length, 22 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland, Six-mile House.

Collection.—Maryland Geological Survey.

Genus DIAPHOROSTOMA Fischer

DIAPHOROSTOMA NIAGARENSE Hall

Plate XXX, Figs. 12-15

Platystoma niagarense Hall, 1852, Pal. N. Y., vol. ii, p. 286, pl. lx.
Diaphorostoma niagarense Hall, 1903, N. Y. State Mus. Mem. 5, p. 59, pl. x, figs. 14-16.

Description.—"Globose, volutions three or four; body-whorl large, inflated toward the aperture which is dilated; suture deep; spire depressed (rarely elevated); shell thin; surface striated across the volutions, and in well preserved specimens longitudinally marked by filiform undulating striæ."—Hall, 1852.

The longitudinal striæ are often not discernible. Diameter, 20 mm.

Occurrence.—MCKENZIE FORMATION. Cedar Cliff, Rose Hill, Maryland. ROCHESTER FORMATION. Rose Hill, Cumberland, Six-mile House, Flintstone, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

CLASS EUTHYNEURA

Order OPISTHOBRANCHIA

Suborder PTEROPODA

Family CAVOLINIIDAE

Genus STYLIOLA Lesueur

STYLIOLA sp.

Plate XXX, Fig. 16

Description.—Shell conical, slender, straight, test very thin. Surface smooth with the exception of very faint growth lines in anterior portion. Apical angle about 10°.

The only specimen seen has been fissured from one end to the other, probably through the collapse of the thin-walled shell.

Probable length of the entire individual about 45 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland, Flintstone.

Collection.—Maryland Geological Survey.

Genus COLEOLUS Hall

COLEOLUS INTERSTRIATUS Prouty n. sp.

Plate XXX, Figs. 17, 18

Description.—Shell conical, straight, tapering very slowly; test thin. Surface marked by prominent oblique striations at distances apart from half to one diameter of the shell, between which are numerous fine striations, the number between the more prominent striæ varying from four to seven.

Probable length, about 40 mm.; maximum diameter, 2.3 mm.

Occurrence.—ROCHESTER FORMATION. Cumberland.

Collection.—Maryland Geological Survey.

Suborder CONULARIIDAE

Family TENTACULIDAE

Genus TENTACULITES Schlotheim

TENTACULITES MINUTUS Hall

Plate XXX, Figs. 24, 25

Tentaculites minutus Hall, 1843, Geol. N. Y., vol. iv, pp. 72, 74, fig. 11.
Tentaculites minutus Hall, 1852, Pal. N. Y., vol. ii, p. 183, pl. A41, figs. 8a-e.
Tentaculites minutus Hall, 1888, Pal. N. Y., vol. vii, p. 5 of suppl., pl. cxiv, figs. 1, 2.
Tentaculites minutus Lesley, 1890, Geol. Survey Penn. Rept. P4, p. 1177, figs.

Description.—" Tubes single, straight, rigid, minute, annulated; annulations extending to the apex, obtuse or rounded, distant three or four times their thickness; intermediate spaces smooth. Length $\frac{1}{8}$ in. This little tentaculite is found in the green shale, and from being extremely minute its characters are not always well preserved. In length it is from $\frac{1}{8}$ in. to $\frac{3}{16}$ in. and is marked by from 15 to 20 annulations. I am unable to distinguish either longitudinal or transverse striæ between or on the annulations. On two specimens measured there are 17 annulations in the $\frac{1}{8}$ in. The annulations are usually sharp rings, rising abruptly from the tube and comparatively distant from each other."—Hall, 1853.

The Maryland forms agree almost exaetly in size and surfaee markings with Hall's figures, being on an average about $\frac{3}{16}$ in. long, possessing fine longitudinal striæ and bearing finer annulations between the larger ones.

This speeies is espeeially abundant about 50 feet above the lower iron sandstone.

Length, 4 mm. to 5 mm.

Occurrence.—ROSE HILL FORMATION. Pinto, Cresaptown, Cumberland, Six-mile House, Maryland; Sir Johns Run, West Virginia; Keefer Mountain, Pennsylvania.

Collection.—Maryland Geologieal Survey.

TENTACULITES NIAGARENSIS Hall

Plate XXXI, Figs. 5, 6

Tentaculites niagarensis Hall, 1852, Pal. N. Y., vol. ii, p. 352, pl. lxxxv, figs. 11, 12.

Tentaculites niagarensis Hall, 1879, Pal. N. Y., vol. v, pt. 2, p. 160.

Tentaculites niagarensis Lesley, 1890, Geol. Survey Penn, Rept. P4, p. 1177, figs.

Tentaculites niagarensis Ami, 1895, Proc. and Trans. Nova Scotian Inst., vol. viii, p. 411 (loc. occ.).

Description.—" Slender, aeute; annulations rounded, eight or nine in the space of $\frac{1}{8}$ in.; intermediate spaees marked by transverse rounded striæ."—Hall, 1852.

Length of average shell, 7 mm.; diameter, 1 mm.

Occurrence.—MCKENZIE FORMATION. Pinto, Cedar Cliff, Six-mile House, Flintstone. ROCHESTER FORMATION. Pinto, Rose Hill, Six-mile House, east of Tonoloway.

Collection.—Maryland Geologieal Survey.

TENTACULITES NIAGARENSIS var. CUMBERLANDIAE Hall

Plate XXXI, Figs, 1-4

Tentaculites niagarensis var. *cumberlandiae* Hall, 1888, Pal. N. Y., vol. vii, p. 5, suppl. pl. cxiv, figs. 3-6.

Description.—" Differs from *T. niagarensis* Hall in its more conspieuous interstitial annulations and more attenuate form."—Hall, 1888.

This form approaches *T. gyracanthus* of the Helderberg in many ways.

Length of average shell, 12 mm. to 15 mm.

Occurrence.—McKENZIE FORMATION. Cedar Cliff, Rose Hill, Flintstone. ROCHESTER FORMATION. Rose Hill, Flintstone, east of Tonoloway.

Collections.—Maryland Geological Survey, American Museum of Natural History.

TENTACULITES GYRACANTHUS var. MARYLANDICUS Swartz n. var.

Plate XXX, Figs. 21-23

Tentaculites gyracanthus Weller, 1903, Pal. N. J., vol. iii, p. 264, pl. xxiv, figs. 19, 20.

Tentaculites gyracanthus Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 486, pl. lxxxvii, fig. 11.

Description.—" Body small, acicular, tapering to an acute point. Annulations rounded, inequally distant, from six to twelve in the space of $\frac{1}{8}$ in.; intermediate spaces marked with rounded annulating striæ. Length rarely more than $\frac{1}{2}$ in."—Hall, 1859.

" Shell elongate, circular in cross-section, annulate, gradually tapering to the apex. Annulations smooth, rounded, situated at irregular intervals, from one to three in the space of 1 mm.; the interspaces between the annulations are marked by fine, annular striæ. In internal casts the annulations are smaller and the fine, annular striæ are lacking from the interspaces."—Weller, 1903.

The Maryland specimens of this shell differ from the typical form in the Manlius of New York in having a smaller apical angle and in being more nearly cylindrical anteriorly, as well as in attaining a much greater length. They have been referred to the typical form by earlier students of the Devonian and Silurian faunas of this state, but appear to the author to be distinct varietally if not specifically. They accord well with Weller's figures of the shells found in New Jersey.

This variety is found both in the Tonoloway and Keyser limestones of Maryland.

A large individual is 15 mm. long, 1.5 mm. diameter.

Occurrence.—TONOLOWAY FORMATION. Pinto, Mullen's Quarry, Cumberland, National Road on Martin Mountain, Maryland; Keyser-Heddenville Road and in Quarry of Standard Lime and Stone Company, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Family CONULARIIDAE

Genus CONULARIA Miller

CONULARIA NIAGARENSIS Hall

Plate XXX, Figs. 26, 27

Conularia quadrisulcata Hall, 1843, Geol. Rept. 4th Dist., p. 110, fig. 2.
Conularia niagarensis Hall, 1852, Pal. N. Y., vol. ii, p. 294, pl. lxv, figs. 1a-h.
Conularia niagarensis Foerste, 1889, Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 286, pl. v, fig. 16.
Conularia niagarensis Foerste, 1898, Geol. Survey Ohio, Pal. vol. vii, p. 547, pl. xxx, fig. 16.
Conularia niagarensis Grabau, 1901, Bull. N. Y. State Mus., No. 45, p. 214, fig. 145.
Conularia niagarensis Grabau, 1901, Bull. Buffalo Soc. Nat. Sci., vol. vii, p. 214, fig. 145.

Description.—"Broad, pyramidal, tapering abruptly, angles with deep abrupt channels, center of each side with a shallow, scarcely defined depression which produces a more abrupt bending of the striæ. Transverse striæ fine and closely arranged, directed from the angles obliquely to the center, where they are more abruptly bent in crossing the slight depression; striæ papillose-granulate, intermediate spaces marked by longitudinal striæ and grooves which alternate with the points upon the transverse striæ."—Hall, 1852.

Only one piece of a shell has been discovered from the Maryland deposits, but careful inspection shows the markings to be identical with the figured material from the New York Rochester and the lower Lockport.

Diameter, about 7 mm. ?

Occurrence.—ROCHESTER FORMATION. Rose Hill, east of Tonoloway.

Collection.—Maryland Geological Survey.

CLASS CEPHALOPODA
Subclass TETRABRANCHIATA
Order NAUTILOIDEA
Suborder ORTHOCHOANITES
Division ORTHOCERATIDA
Family ORTHOCERATIDAE
Genus ORTHOCERAS Breyn
ORTHOCERAS BASSLERI Prouty n. sp.

Plate XXXI, Figs. 7-9

Description.—Shell conical, tapering uniformly, apical angle about 16°, cross-section circular; septa numerous, concave, separated by a space equal to about one-tenth the diameter of the shell; sutures slightly curved. Siphuncle excentric, slightly ventral in position, somewhat nummuloid; diameter of siphuncle very slightly greater than the distance between septa.

Diameter, 25 mm. to 30 mm.

Occurrence.—ROSE HILL FORMATION. Pinto, in lower beds, usually not well preserved.

Collection.—Maryland Geological Survey.

ORTHOCERAS MCKENZICUM Prouty n. sp.

Plate XXXII, Figs. 1, 2; Plate XXXIII, Fig. 1

Description.—Large, gradually tapering, septæ thin, moderately arched, close, usually about 6 mm. apart or about one-eighth diameter of shell; siphuncle medium to small in size, very strongly nummuloidal or moniliform, subcentral. This species is usually found about 90 feet below the top of the McKenzie formation.

Diameter of base of last chamber 55 mm.

Occurrence.—MCKENZIE FORMATION. Cedar Cliff, Rose Hill, Cumberland, Flintstone, east of Tonoloway, Rabble Run, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

ORTHOCERAS sp.

Plate XXX, Figs. 19, 20

Description.—Shell straight, small; apical angle very small; siphuncle subcentral; air chambers very shallow, depth about one-fourth their width. Exterior and chamber of habitation unknown.

Diameter of largest air chamber of specimen observed is 6 mm.; depth, 1.5 mm.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Family CYCLOCERATIDAE

Genus CYCLOCERAS McCoy

CYCLOCERAS CLINTONI Prouty n. sp.

Plate XXXII, Figs. 7, 8

Description.—Small, gently tapering with oblique, close-set, rounded annulations which are about six in number in space equal to width of shell; septa moderately convex, from one-third to one-fourth width of shell apart; siphuncle small and centrally located. The specimen figured is the only individual of this species seen.

Diameter, 3.6 mm.

Occurrence.—ROCHESTER FORMATION. Six-mile House.

Collection.—Maryland Geological Survey.

Division PLECTOCERATIDA

Family PLECTOCERATIDAE

Genus SPHYRADOCERAS Hyatt

SPHYRADOCERAS cf. DESPLAINENSE McChesney

Plate XXXII, Fig. 3

Trochoceras desplainensis McChesney, 1859, New Pal. Fossils, p. 68, fig. 1.
Trochoceras desplainensis Hall, 1868, 20th Rept. N. Y. State Cab. Nat. Hist., p. 359, pl. xvi, figs. 8, 9, 10.
Trochoceras desplainensis Whiteaves, 1884, Paleozoic Fossils, vol. vii, pt. 1, pl. v, fig. 5.

Trochoceras desplainense Kindle and Breger, 1904, 28th Ann. Rept. Dep. Geol. Nat. Res. Indiana, p. 472.

Sphyradoceras desplainense Grabau and Shimer, 1910, N. A. Index Fos., vol. ii, p. 74, fig. 1286.

Description.—"Shell very slightly trochiform, suborbicular in outline, spire not elevated; volutions about three, expanding very moderately with the growth of the shell, contiguous; section subelliptical, dorso-ventral diameter greater than the lateral; dorsum strongly convex, ventral side slightly flattened or impressed by the convexity of the preceding volution; septa convex, distant from each other in the middle of the outer volution on the dorsum about three lines (¼ in.); umbilicus broad and shallow, siphuncle not distinctly seen.

"Surface marked by numerous strong, obliquely transverse, angular or sharply rounded ridges, strongly arching back on the dorsum, and increasing in distance from each other with the age of the shell; the spaces intervening these ridges are regularly concave; minute surface character unknown."—McChesney, 1859.

Occurrence.—ROCHESTER FORMATION. Cumberland, Maryland. ROSE HILL FORMATION. Devil's Nose, near Sir Johns Run, West Virginia.

Collection.—Maryland Geological Survey.

Division HERCOCERATIDA

Family HERCOCERATIDAE

Genus TROCHOCERAS Barrande

TROCHOCERAS (?) MARYLANDICUM Swartz n. sp.

Plate XXXII, Figs. 4-6

Description.—Shell small, spirally coiled; spire low; volutions increasing in diameter very gradually from apex; umbilicus deep, its diameter about one-half that of chamber of habitation. Chamber of habitation appears to be slightly curved, free at mouth; aperture unknown. Air chambers shallow, their width about eight times their depth; septa concave, their convexity equalling their depth; siphuncle moniliform, ventral, marginal, its divisions oblique, its diameter 2 mm. anteriorly.

This species is based upon fragmentary material rendering its generic relations somewhat insecure.

Dimensions of shell, about 30 mm.; diameter of chamber of habitation, 13 mm.; depth of anterior air chambers, about 1 mm.

Occurrence.—TONOLOWAY FORMATION. Mullen's Quarry, Cumberland, associated with *Tetrameroceras cumberlandicum.*

Collection.—Maryland Geological Survey.

Suborder CYRTOCHOANITES

Division ACTINOSIPHONATA

Family ONCOCERATIDAE

Genus ONOCERAS Hall

ONOCERAS MCKENZICUM Prouty n. sp.

Plate XXXIII, Fig. 1

Description.—Shell subfusiform, slightly curved; tapering strongly near apex; living chamber large, nearly half the length of shell; air chambers numerous, subequal in depth, save uppermost one which is shallower; septa moderately arched, distant about one-tenth maximum diameter of the shell. The dorsal margin is regularly convex; the vertical margin is convex over living chamber, concave towards apex. The specimen figured was the only one observed.

Length, 45 mm.; maximum dorso-ventral diameter, 27 mm.

Occurrence.—MCKENZIE FORMATION. Cedar Cliff.

Collection.—Maryland Geological Survey.

Family TRIMEROCERATIDAE

Genus TETRAMEROCERAS Hyatt

TETRAMEROCERAS CUMBERLANDICUM Swartz n. sp.

Plate XXXIII, Figs. 2-4

Description.—Shell pyriform, arcuate, dorsally convex, point of greatest width near or slightly anterior to middle of chamber of habitation, thence contracting towards apex. Chamber of habitation a little less than half the length of shell, rounded anteriorly, its cross-section elliptical, its transverse diameter being about three-fourths its dorso-ventral diameter in uncompressed specimens; its length equalling or a little less than its dorso-ventral diameter. Aperture T-shaped, deeply lobed, dividing dorsally into four lobes; extremity of lobes rounded, dorsal pair longer, separated dorsally by a deep sinus. The aperture ends ventrally in an oval opening which is connected by a narrow slit with the dorsal lobes.

Air chambers shallow, curved, depth of two or three chambers next chamber of habitation about one-eighth their greatest width; depth of succeeding one-fourth to one-fifth greatest width. Surface and siphuncle not observed.

The outline of the aperture was observed on but two specimens preserving the chamber of habitation only. It is not therefore entirely sure that the individuals preserving the air chambers are of the same species, although this conclusion seems probable. A number of the specimens observed are distorted by compression.

Chamber of habitation of type individual has length, 15 mm.; lesser diameter, 15 mm.; greater diameter, 18 mm. In a larger individual preserving six air chambers, length of shell is 37 mm.; length of chamber of habitation, 20 mm.; greatest diameter, 25 mm.

Occurrence.—TONOLOWAY FORMATION. Mullen's Quarry, Cumberland, Maryland; Hyndman, Pennsylvania.

Collection.—Maryland Geological Survey.

TETRAMEROCERAS CUMBERLANDICUM var. MAGNACAMERATUM Swartz n. var.

Plate XXXIII, Figs. 5, 6

Description.—This variety differs from the typical form in the greater proportionate depth of its anterior air chambers. The air chamber next to the chamber of habitation is shallow, the depth of the succeeding ones being about one-fifth their greatest width. This variety is represented by but three specimens. Further collections may show it to be distinct.

A specimen preserving five air chambers gave length of shell, 48 mm.; length of chamber of habitation, 25 mm.; greatest diameter, 28 mm.

Occurrence.—TONOLOWAY FORMATION. Mullen's Quarry, Cumberland.

Collection.—Maryland Geological Survey.

ARTHROPODA

CLASS CRUSTACEA

Superorder OSTRACODA

Family LEPERDITIIDAE

Genus LEPERDITIA Rouault

Examples of this prolific genus are quite abundant in the higher Silurian strata of the Eastern United States but the species are so closely related to the equally well represented Early Devonian species that their close discrimination can only be made after a more intensive study of the genus than is possible at present. In most instances the Maryland Silurian forms have been identified as varieties of Early Devonian species, but when edge views of the related forms have been prepared and compared the varieties will probably be found to be worthy of specific rank.

LEPERDITIA ELONGATA WILLSENSIS new variety

Plate XXXVI, Figs. 3-6

Cf. *Leperditia elongata* Weller, 1903, Geol. Surv. New Jersey, Rep. Pal. iii, p. 259, pl. xxiii, fig. 13.

Description.—The numerous specimens upon which this variety is founded seem to represent a somewhat smaller, earlier form of the type of *L. elongata.* (See Plate XXXVI, Figs. 1, 2.) They are much less convex and higher in the antero-ventral region. Furthermore the eye spot is further removed from the anterior extremity and the valves are also slightly shorter. Average length, 8.0 mm.; height, 4.5 mm.

Occurrence.—WILLS CREEK FORMATION. Pinto (48 feet above base), Cedar Bluff (172 feet above base) and Cumberland, Maryland (235 feet above base).

Collection.—Maryland Geological Survey.

LEPERDITIA MATHEWSI n. sp.

Plate XXXVI, Figs. 7, 8

Description.—This well-marked species although allied to several Silurian and Early Devonian forms is easily distinguished from its nearest allies by the well-defined border on each valve. It is perhaps closest to *L. elongata* Weller, but is less convex and the border is better developed. Length, 6.0 mm.; height, 3.9 mm.

The specific name is in honor of Dr. E. B. Mathews, State Geologist of Maryland, to whom more than anyone else besides the authors the publication of the present work is due.

Occurrence.—TONOLOWAY LIMESTONE. Grasshopper Run section near Hancock, Maryland.

Collection.—Maryland Geological Survey.

LEPERDITIA ALTOIDES MARYLANDICA n. var.

Plate XXXVI, Fig. 11

Cf. *Leperditia altoides* Weller, 1903, Geol. Surv. New Jersey, Pal. iii, p. 252, pl. xxiii, figs. 1, 2.

Description.—Although related to *L. altoides* Weller (see Plate XXXVI Figs. 9, 10) from the Lowest Devonian of New Jersey (Rondout formation) and Maryland (Keyser formation) the present form clearly is not the same, being higher posteriorly and the anterior outline less regularly rounded. Length, 7.0 mm.; height, 3.0 mm.

Occurrence.—WILLS CREEK FORMATION. 182 feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

LEPERDITIA SCALARIS PRÆCEDENS n. var.

Plate XXXVI, Figs. 12, 13

Cf. *Leperditia gibbera scalaris* Jones, 1858, Ann. Mag. Nat. Hist., 3d ser. 1, p. 250, pl. x, figs. 10, 11.

Description.—The exact relationships of the various forms referred by authors to *Leperditia scalaris* have not yet been determined, indeed the limits of the species itself are still unknown. Under these circumstances it seems best to designate the Maryland Silurian form as a new variety. Length, 5.0 mm.; height, 4.0 mm.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Keyser, West Virginia, and Pinto, Maryland.

Collection.—Maryland Geological Survey.

Leperditia alta (Conrad) Jones

Plate XXXVI, Figs. 14-17

Leperditia alta (Conrad) Jones, 1856, Ann. Mag. Nat. Hist., 2d ser., vol. xvii, p. 88, pl. vii, figs. 6, 7.

Description.—Specimens resembling this species which occurs so abundantly in the Manlius limestone of New York are found in equal abundance in numerous zones throughout the McKenzie, Wills Creek and Tonoloway formations of Maryland and neighboring states and are so identified in the detailed stratigraphic sections. Figures of both New York and Maryland examples are given on Plate XXXVI for comparison, but it is possible that future studies will reveal the presence of several distinct varieties, if not species, among these numerous occurrences.

Occurrence.—Abundant in the McKenzie, Wills Creek and Tonoloway formations of Maryland and neighboring states. A characteristic fossil of the Manlius limestone of New York.

Collection.—Maryland Geological Survey.

Leperditia alta cacaponensis n. var.

Plate XXXVI, Fig. 18

Description.—This variety differs from the typical form of the species in the outline of the anterior side, in the eye spot which is more clearly indicated, and in the ventral slope which descends more gradually than in typical *L. alta*. Length, 7.1 mm.; height, 4.6 mm.

Occurrence.—Clinton (*Drepanellina clarki* zone). Four feet above Keefer sandstone, 1½ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

Leperditia alta brevicula n. var.

Plate XXXVI, Fig. 19

Description.—As indicated in the varietal name this form is distinguished from typical *L. alta* by the relative shortness of its valves, which moreover are much smaller. Length, 3.0 mm.; height, 2.0 mm.

Occurrence.—WILLS CREEK FORMATION. 120 feet below the top at Pinto, Maryland.

Collection.—Maryland Geological Survey.

Family APARCHITIDAE new family

Genus APARCHITES Jones

APARCHITES (?) OBLIQUATUS n. sp.

Plate XXXVI, Fig. 23

Description.—Of the simple, straight-hinged *Aparchites*-like ostracoda none has been described that matches this in anterior narrowness, general obliquity of outline, and surface markings. The large, smooth spot in the middle of the dorsal three-fifths of the valve together with the shallow pits arranged in radial series about it make a characteristic marking. As to its generic position it is not at all certain that this is a true *Aparchites*. The smooth spot mentioned suggests *Kirkbya* and certain species of *Primitia*. However, until these simple or merely bilobed Beyrichiacea have been subjected to critical and comprehensive investigation more or less of artificiality of classification is to be expected. Length, 2.0 mm.; height, 1.25 mm.

Occurrence.—TONOLOWAY LIMESTONE. Near top at Keyser, W. Va., and at other localities in the upper part of the formation.

Collection.—Maryland Geological Survey.

APARCHITES (?) PUNCTILLOSA n. sp.

Plate XXXVI, Fig. 21

Description.—Though falling well within the prevailing loose definition of *Aparchites* we are far from satisfied that this is really a congener of the Ordovician type of the genus. There is a small, smooth median spot and around this to all parts of the edge the moderately convex surface is covered with distinct punctæ. There is no border of any kind. As in the case of *Aparchites obliquatus* this also may prove to be an ally of *Kirkbya* rather than *Aparchites*. Length, 0.80 mm.; height, 0.60 mm.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Keyser, W. Va.

Collection.—Maryland Geological Survey.

APARCHITES (?) VARIOLATUS n. sp.

Plate XXXVI, Fig. 20

Description.—This minute species, although doubtful in its generic affinities, is easily recognized by its rounded outline and by the rather large and widely spaced pores or pits ornamenting the surface of the valves. Length, 0.50 mm.; height, 0.40 mm.

Occurrence.—CLINTON. Fifty-seven feet above Tuscarora sandstone along Wills Creek at Cumberland, Md.

Collection.—Maryland Geological Survey.

APARCHITES ALLEGHANIENSIS n. sp.

Plate XXXVI, Fig. 22

Description.—The small short, subovate valves of this species with their smooth surface and undefined dorsal angles are so different from all other Appalachian Silurian ostracoda that a detailed description seems unnecessary.

Occurrence.—CLINTON. (*Drepanellina clarki* zone), 5 feet below top at Cumberland, Md.

Collection.—Maryland Geological Survey.

Genus ERIDOCONCHA new genus

ERIDOCONCHA ROTUNDA n. sp.

Plate XXXVI, Fig. 24

Description.—This is an altogether peculiar ostracod. Its dorsal side projects beyond the short but straight hinge line in a manner to suggest certain brachiopods. Something like this occurs in the new Ordovician genus *Eridoconcha.* The irregularly concentric rows of punctæ, the thickened ventral lip, subovate form, and rounded dorsal outline are its most characteristic features. Length, 0.70 mm.; height, 0.55 mm.

Occurrence.—CLINTON. *Mastigobolbina typus* zone, at Lakemont, Pa.

Collection.—U. S. National Museum.

Superfamily BEYRICHIACEA

Family PRIMITIIDAE new family

Genus PRIMITIELLA Ulrich

PRIMITIELLA EQUILATERALIS n. sp.

Plate XXXVII, Fig. 28

Description.—The species of these very simple ostracods are naturally very similar to each other, but *Primitiella equilateralis* may be distinguished by its elongate form, small size, and equal ends. The general outline is as in the typical Ordovician species, but the slight mesial depression is scarcely observable. Length, 0.55 mm.; height, 0.3 mm.

Occurrence.—CLINTON. *Drepanellina clarki* zone at McKees farm, 7 miles west of Lewiston, Pa.

Collection.—U. S. National Museum.

Genus EUPRIMITIA new genus

EUPRIMITIA BUTTSI n. sp.

Plate XXXVII, Figs. 1, 2

Description.—In spite of the numerous species referred to *Primitia* the present new form named in honor of Mr. Charles Butts is readily distinguished by its comparatively large size and especially by the well-developed furrow and the delicate surface reticulation. The species is further interesting in that a closely allied form, differing only in wanting the surface reticulation, is present in the Gun River formation of Anticosti Island. Length, 1.5 mm.; height, 1.1 mm.

Occurrence.—CLINTON. *Zygobolba erecta* zone, 1½ miles southwest of Cherrytown, Pa.

Collection.—U. S. National Museum.

Genus LACCOPRIMITIA new genus

LACCOPRIMITIA BASSLERI n. sp.

Plate XXXVII, Fig. 3

Description.—This new species, named in honor of Dr. Charles E. Resser, belongs to that section of this prolific genus in which the furrow is replaced by a well-defined, more or less elongated pit in the middle of the dorsal half. The material so far collected is not sufficient for a detailed description, but the scarcity of Primitian Ostracoda in the Silurian rocks of the Appalachian region warrants its recognition. Length, 0.60 mm.; height, 0.35 mm.

Primitia humilis Jones and Holl from the Silurian of Europe is perhaps the closest ally, but the exact characters of that species have not yet been determined.

Occurrence.—CLINTON. *Drepanellina clarki* zone, 5 feet below top, at Cumberland, Md.

Collection.—Maryland Geological Survey.

Genus PARÆCHMINA new genus

PARÆCHMINA SPINOSA (Hall)

Plate XXXVIII, Figs. 1-3

Cytherina spinosa Hall, 1852, Nat. Hist. New York, Pal. II, p. 317, pl. lxvii, figs. 17-21.

Description.—*Paræchmina spinosa* is distinguished from other species by its rather short, subequally ended (very slightly oblique) valves, distinctly depressed over their median parts, the depressed area enclosed by a strong wall-like ridge of equal thickness and height around the ends and ventral side. The spine is large, sharply pointed and high. The pit lies as usual on the posterior side of its base. Average specimens. Length, 0.95 mm.; height without spine, 0.6 mm.

Occurrence.—CLINTON. *Drepanellina clarki* zone at Cumberland and other localities in Maryland and at McKees farm, 7 miles west of Lewiston, Hollidaysburg, etc., Pennsylvania. Exceedingly abundant in the Rochester shale of western New York.

Collection.—Maryland Geological Survey.

PARÆCHMINA CRASSA n. sp.

Plate XXXVIII, Fig. 14

Description.—Is distinguished from *P. spinosa* which probably is nearer than any of the other species now recognized by its much thicker marginal ridge and consequently much smaller size of the depressed space between the outer ridge and the base of the spines. The anterior end also is lower so that the outline of the valves is correspondingly more oblique. In other directions the species simulates *P. postica* but differs decidedly from that species in the proportionally lesser elevation of the posterior part of the ridge and its greater height in the anterior half. In fact the marginal ridge in *P. postica* declines anteriorly and passes over into a much lower and less defined diagonal convexity. Profile views of the two species therefore are very different. In most of its features *P. crassa* may be said to be intermediate between the two others with which it has been compared. Length, 1.0 mm.; height without spine, 0.6 mm.

Occurrence.—CLINTON (*Mastigobolbina typus* zone), Hollidaysburg, Pennsylvania.

Collection.—U. S. National Museum.

PARÆCHMINA ABNORMIS Ulrich

Plate XXXVIII, Fig. 11

Aechmina abnormis Ulrich, 1890, Journal Cincinnati Soc. Nat. Hist., XIII, p. 183, pl. xii, figs. 7a, 7b.

This species is generally associated with *P. spinosa* (Hall) but it is easily distinguished by it larger size, and by the division of the marginal ridge into two large, unsymmetrically arranged lobes giving the valve an abnormal appearance. Length, 1.0 mm.; height without spine, 0.65 mm.

Occurrence.—CLINTON. Rochester shales at Lockport and other localities in Western New York. Abundant in the *Drepanellina clarki* zone at Rose Hill and other localities in Maryland.

Collection.—U. S. National Museum.

PARÆCHMINA POSTICA n. sp.

Plate XXXVIII, Figs. 6-10

Description.—*Paræchmina postica* has a thick, high and rather undefined posterior ridge which lowers as it turns down to the ventral side and thence passes in antero-dorsal direction into a still lower broad convexity. In edge view therefore the posterior end is thick, the profile descending at first slowly and then with increasing rapidity to the anterior edge. These features distinguish the species from *P. crassa* to which probably it is more closely related than to any other now known. It might also be compared with *P. spinosa* and *P. abnormis,* but it certainly is distinct from both of the Rochester shale species. The latter of these perhaps is the nearer of the two but the ventrally broken marginal ridge gives it a strikingly different aspect. Length of average specimen, 1.1 mm; height without spine, 0.6 mm.

Occurrence.—CLINTON. Common in the *Drepanellina clarki* zone at Cumberland and other localities in Maryland and in the same zone at Lakemont, Hollidaysburg, McKees farm 7 miles west of Lewiston, etc., Pennsylvania.

Collection.—Maryland Geological Survey.

PARÆCHMINA INTERMEDIA n. sp.

Plate XXXVIII, Figs. 12, 13

Description.—It differs from *P. spinosa* in its more elongate form and incomplete and thinner marginal ridge. This fails on the anterior side. It is perhaps no less closely related to *P. altimuralis* but it also has the marginal ridge continued around the anterior end. In *P. postmuralis* the shape of the valves is different and the incomplete ridge farther from the edge. In *P. inæqualis,* a McKenzie formation species, the outline is somewhat different, the antero-dorsal edge descends more abruptly and the marginal ridge, which in that species is confined to the posterior half, rises more abruptly and to greater height. Length, 1.1 mm.; height without spine, 0.55 mm.

Occurrence.—CLINTON. *Drepanellina clarki* zone. McKees farm, 7 miles west of Lewiston, Pennsylvania.

Collection.—U. S. National Museum.

Paræchmina altimuralis n. sp.

Plate XXXVIII, Figs. 23-26

Description.—This well-marked species is allied to *Paræchmina spinosa* (Hall) but the valves are more elongate and the marginal ridge very high, thin and sharply keeled. Length, 2.0 mm.; height without spine, 0.6 mm.

Occurrence.—Clinton. *Drepanellina clarki* zone at McKees farm, 7 miles west of Lewiston, Pennsylvania.

Collection.—U. S. National Museum.

Paræchmina depressa n. sp.

Plate XXXVIII, Fig. 22

Description.—Related to *P. spinosa* and *P. altimuralis* agreeing with those species in having a continuous and unchanging high marginal wall around the ends and ventral side. The marginal ridge curves well on to the dorsal edge, this feature being more striking in *P. depressa* than in the mentioned Upper Clinton species. It differs further in that the ends are less nearly equal the anterior being considerably narrower than the posterior; and on both ends the outer is more convexly curved inward in passing into the dorsal edge. In other words the dorsal angles are more obtuse. Length, 0.85 mm.; height without spine, 0.50 mm.

Occurrence.—McKenzie Formation. Middle portion at Cumberland, Maryland.

Collection.—U. S. National Museum.

Paræchmina postmuralis n. sp.

Plate XXXVIII, Fig. 19

Description.—The distinguishing characters of this species are (1) its elongate and anteriorly tapering form, (2) the restriction of the curved submarginal ridge to the posterior half and (3) the unusual width of the visible part of the slope outside of the marginal ridge. The spine is broken but judging from the remaining base it was probably small and sharply pointed. There are other species in which the marginal ridge is incomplete but their other characters are too different to require detailed comparison. Length, 1.0 mm.; height without spine, 0.6 mm.

Occurrence.—CLINTON, *Zygobolbina emaciata* zone. Near tollgate, Cove Gap, 4½ miles northwest of Mercersburg, Pennsylvania.

Collection.—U. S. National Museum.

PARÆCHMINA BIMURALIS n. sp.

Plate XXXVIII, Fig. 15

Description.—The distinctive feature of this species is the small wall-like ridge around the ventral and lateral side of the base of the spine which unfortunately was broken away in cleaning. The marginal ridge is high and thin and extends all around from angle to angle. The umbilical pit lies as usual on the posterior side of the base of the spine. The depressed convex area between the inner and outer ridges is punctate. This combination of characters distinguished the species readily enough from all others and particularly from such of its nearer allies as *P. altimuralis, P. spinosa, P. depressa* and *P. punctata*. Length, 0.85 mm.; height, 0.5 mm.

Occurrence.—MCKENZIE FORMATION, 20 feet above base. One and one-half miles east of Great Cacapon, West Virginia.

Collection.—U. S. National Museum.

PARÆCHMINA INÆQUALIS n. sp.

Plate XXXVIII, Figs. 16-18

Description.—The relations of this species seem to be with *P. intermedia* and *P. postmuralis* with which it agrees in the restriction of its marginal ridge to the posterior half. In the anterior half the margin is merely raised a trifle before descending abruptly to the contact edge. The species differs from its allies in the abrupt elevation and extraordinary height of the dorsal half of the posterior marginal ridge. Because of its height and vertical sides the ridge commonly is more or less broken away in freeing specimens from the limestone matrix in which they occur. The spine is thick and strong in its lower half but tapers above gradually to a fine point. Length, 0.80 mm.; height without spine, 0.40 mm.

Occurrence.—MCKENZIE FORMATION. 73 and 82 feet below top. Flintstone, Maryland.

Collection.—U. S. National Museum.

PARÆCHMINA CUMBERLANDIA n. sp.

Plate XXXVIII, Fig. 4

Description.—This species is thought to be most closely related to *P. punctata* having a similarly coarsely punctate surface and nearly the same outlines. But the spine, of which only the base remains in the type specimen, is located much farther forward, nearly in the middle of the anterior half and hence much farther from the umbilical pit than in either that or any other species. The marginal ridge is very low and the punctation of the very gently convex median area extends almost to the edge. Length, 1.00 mm.; height, 0.60 mm.

Occurrence.—CLINTON. *Drepanellina clarki* zone at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

PARÆCHMINA PUNCTATA n. sp.

Plate XXXVIII, Fig. 21

Description.—This is a typical species of the genus with a long spine and rather low marginal ridge. The ends are somewhat unequal, the anterior being slightly narrower and with a rather well-marked dorsal angle. The inner area is not deeply depressed and its surface is covered with distinct and rather large punctæ. The low ridge enclosing the punctate area is smooth. Though related to *P. spinosa* and *P. depressa* the punctate inner area, low marginal ridge and sharper antero-dorsal angle should serve very well in distinguishing them. Length, 0.8 mm.; height without spine, 0.5 mm.

Occurrence.—CLINTON. *Mastigobolbina typus* zone, two miles west of Hollidaysburg, Pennsylvania.

Collection.—U. S. National Museum.

PARÆCHMINA ? DUBIA n. sp.

Plate XXXVIII, Fig. 5

Description.—The generic position of this small species is doubtful. The type specimen is a right valve and not so well preserved as is desirable. There is a suggestion of *Ctenobolbina* (*e. g., C. minima*) but it would seem unnaturally placed in that genus. The small node behind the broadly depressed middle of the dorsal half is believed to give a truer clue to its systematic position. So far as can be seen the specimen presents nothing positively opposed to its reference to *Paræchmina*. The size of the spine varies greatly in this genus, being small in some. Aside from the relatively minute size of the spine the species is not greatly different from *P. postica*. Another difference when compared with that older (Lakemont) species is that the convex part of its surface is minutely yet distinctly punctate instead of smooth. There is also more of a flattened border around the ends. Length, 0.60 mm.; height, 0.40 mm.

Occurrence.—TONOLOWAY LIMESTONE. Upper part, Keyser, West Virginia.

Collection.—Maryland Geological Survey.

Genus ÆCHMINA Jones and Holl

ÆCHMINA SIMPLEX n. sp.

Plate XXXVIII, Fig. 20

Description.—A simple unridged species suggesting *Æchmina bovina* Jones and Holl but less evenly convex. In fact the surface is flat or even slightly concave in front of the middle of the valves. Length, 0.9 mm.; height without spine, 0.50 mm.

Occurrence.—CLINTON. *Drepanellina clarki* zone. McKees farm, 7 miles west of Lewiston, Pennsylvania.

Collection.—U. S. National Museum.

Genus BOLLIA Jones and Holl

BOLLIA PULCHELLA n. sp.

Plate XXXVII, Figs. 26, 27

Description.—This is a fine and apparently quite typical species of *Bollia.* It is one of the largest known and more elongate and more convex than usual. The horseshoe-shaped thin ridge which incloses the umbilical pit lies about midlength of the dorsal half. Then there is a thin but otherwise well-developed submarginal ridge. It lies near yet clearly within the extreme edge. This outwardly sloping marginal strip is characteristic. In nearly all the other species the ridge is quite marginal with the edge dropping vertically or with concave overhang from the base of the ridge. Between the two ridges the surface is more than usually convex and covered with a fine network of angular pores. Some of the specimens show a peculiar low swelling between the bottom of the loop and the ventral edge. These may be females. Length, 0.90 mm.; height, 0.50 mm.

Compared with *Bollia immersa* and *B. nitida,* the present species differs mainly in the greater convexity of the valves and the extension of the anterior edge far beyond the submarginal ridge.

Occurrence.—WILLS CREEK FORMATION. Pinto, Md., 125 feet above base where it is abundant on the surface of thin slabs.

Collections.—Maryland Geological Survey, U. S. National Museum.

BOLLIA IMMERSA n. sp.

Plate XXXVII, Fig. 24

Description.—This is a smaller ostracod than *Bollia pulchella,* which occurs 80 feet higher in the same formation—the Wills Creek—at Pinto. Its valves agree with those of that species in being uncommonly convex and finely reticulated but differ in many other respects. It is a shorter form, with the outer ridge at the extreme edge, and the inner ridge very low and failing to reach the dorsal edge. No other species known to us looks very much like it. *B. nitida,* which is found with this in the Wills Creek formation at Pinto, Md., is a much flatter form with a thicker and more oblique horseshoe ridge. Length, 0.60 mm.; height, 0.45 mm.

Strangely all the known Appalachian species of *Bollia* were found at Pinto, Md., in two horizons of the Wills Creek formation.

Occurrence.—WILLS CREEK FORMATION. Pinto, Md., 45 feet above base.

Collection.—Maryland Geological Survey.

BOLLIA NITIDA n. sp.

Plate XXXVII, Fig. 25

Description.—This is distinguished from the other two species of the genus found in the Silurian rocks of Maryland by its flatter and much more obliquely outlined valves. Like the others the area between the marginal and inner ridges is minutely reticulated. However, the inner looped ridge is thicker, oblique, and more prominent, especially toward the dorsal edge. Length, 0.70 mm.; height, 0.45 mm.

Occurrence.—WILLS CREEK FORMATION. Pinto, Md., 45 feet above base.

Collection.—Maryland Geological Survey.

Genus HALLIELLA Ulrich

HALLIELLA FISSURELLA n. sp.

Plate XXXVII, Figs. 22, 23

Description.—Similar to *Halliella seminulum* Jones but has a narrow fissure-like median sulcus. It is interesting to note that the female of this type like so many of the Silurian Beyrichiacea also has a ventral brood pouch. Length, 1.10 mm.; height, 0.60 mm.

Occurrence.—TONOLOWAY LIMESTONE. Upper part, Keyser, W. Va.

Collection.—Maryland Geological Survey.

HALLIELLA SUBEQUATA n. sp.

Plate XXXVII, Fig. 20

Description.—Similar to *Halliella fissurella* but its median sulcus is narrower above and seems to close entirely just before reaching the dorsal edge. The border is narrower on the anterior side but fully as wide and thicker on the posterior end and more depressed on the ventral edge. Finally, the hinge line is shorter and the dorsal angles more obtuse. Length, 1.00 mm.; height, 0.70 mm.

Occurrence.—WILLS CREEK FORMATION. Pinto, Md., 45 feet above base.

Collection.—Maryland Geological Survey.

HALLIELLA ? TRIPLICATA Ulrich and Bassler

Plate XXXVII, Fig. 21

Halliella (?) *triplicata* Ulrich and Bassler, 1913, Maryland Geol. Survey, Lower Dev., p. 521, pl. 93, figs. 17, 18.

Description.—A well-preserved ostracode collected in the Lower Tonoloway limestone at Keyser, W. Va., is so similar to the type of *Halliella ? triplicata* Ulrich and Bassler described from the lowest Devonian at the same place that doubt is possible as to the exact stratigraphic position of the latter. It is possible, of course, that the species may range through both the Tonoloway and Keyser limestones, but it is more probable that the original type of the species was derived from a loose fragment of Tonoloway limestone erroneously identified as Keyser limestone. Length, 0.90 mm.; height, 0.60 mm.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Keyser, W. Va.

Collection.—Maryland Geological Survey.

Subfamily EURYCHILININAE new subfamily

Genus CHILOBOLBINA new genus

Carapace with the broad striated frill characteristic of the subfamily, a simple, short, more or less deeply impressed median furrow or spot, the median lobe barely elevated above general convexity of surface, the male closely resembling the older, simply sulcate section of *Eurychilina*. The female differs in having a prominent long ovate brood pouch that covers approximately the posterior three-fifths of the ventral part of the frill and laps slightly onto the convex part of the valve.

Genotype.—*Chilobolbina* (*Primitia*) *dentifera* Bonnema,[1] Kuckers formation of Esthonia. Typical American species *Chilobolbina punctata* Ulrich and Bassler from the Dyer Bay dolomite (? lower Clinton), near Cabot Head, Lake Huron, Ontario, and in the Gun River and Jupiter River formations of Anticosti Island.

The Kuckers shale contains two other species that seem to belong to this genus. These also were described by Bonnema and referred by him to the genus *Primitia*. *Chilobolbina* (*Primitia*) *kuckersiana* suggests a close ally of our *Chilobolbina hartfordensis,* types of which come from the Middle Clinton, *Mastigobolbina lata* zone, in central New York. The third of the Kuckers species, *C.* (*Primitia*) *kapteyni,* also seems to have a close ally in *C. billingsi* (Jones), which is found associated on the same slabs with *C. punctata* near Cabot Head and in the Gun River and Jupiter River formations in Anticosti.

Besides the six species mentioned, there is a relatively short form of the type of *C. punctata* that is rarely observed in the *Mastigobolbina lata* zone in the vicinity of Cumberland. This is provisionally distinguished as var. *brevis.* It is interesting and perhaps stratigraphically significant to add that the three species of *Chilobolbina* so far observed in the Appalachian region are all confined to the *M. lata* zone of the Clinton.

The species now referred to *Chilobolbina* may be confidently regarded as descendants of two or more of the simply-sulcate group of Eurychilinids for which the new generic term *Cœlochilina* is herein proposed. The only difference that might be considered as of greater than specific value is that the female in the derived forms develops a large and prominent brood pouch on the frill.

CHILOBOLBINA PUNCTATA n. sp.

Plate XXXVII, Figs. 10-12

Description.—Valves rather strongly convex, somewhat unsymmetrical, highest in posterior half, swung slightly backward, the anterior cardinal

[1] *Primitia dentifera* Bonnema, 1909, M. H. Min. Geol. Inst. Gröningen, vol. ii, p. 25, pl. ii, figs. 1-5.

angle sharper than the posterior; sulcus median in position, short and narrow, gently curved around the anterior side of a low swelling that corresponds to the median lobe of the Beyrichiacea; surface minutely puncto-reticulate. Frill wide on ventral side, narrowing toward the cardinal angles, radially striated, concave to a sharp rim from which the surface descends abruptly into the ventral groove; pouch long, subelliptical, prominently convex, clearly defined, smooth. Length about 1.25 mm.; greatest height, excluding frill, 0.65 mm.; greatest width of frill, 0.17 mm.

This species is perhaps as near *Chilobolbina kuckersiana* (Bonnema), an Esthonian fossil, as to any other. Both have a reticulated surface and a low swelling behind the sulcus, but the details of the sulcus are quite different in the two species. In the Esthonian species the sulcus forms a large sharply outlined pit, whereas in *C. punctata* its outline is indefinite.

Occurrence.—The types of the species were collected by Dr. M. Y. Williams in a green shale at the top of the Dyer Bay dolomite at the clay cliffs 2 miles west of Cabot Head, Lake Huron, Ontario. Specimens that we have not succeeded in distinguishing from this species were collected by Schuchert and Twenhofel in Anticosti from zone 5 of their Gun River formation and by M. Y. Williams from limestones along the southeast branch of Blanch River, north of Cobalt, Ontario.

At the Lake Huron locality the species is associated with other new and previously described ostracoda two of which are figured in this work, namely, *Chilobolbina billingsi* (Jones), and *Zygobolba williamsi*. Williams originally referred the Dyer Bay dolomite to the base of the Lockport, but in his final work [1] on the concerned formations he classifies it as a part of the Cabot Head shale which he regards as representing the Cataract formation in northwestern Ontario. The Cataract, it is generally agreed, corresponds to an upper part of the Upper Medinan Albion formation of western New York. In our opinion the reference of the Dyer Bay dolomites to the Medinan is unwarranted. The problem is

[1] Williams, M. Y., The Silurian geology and faunas of Ontario Peninsula and Manitoulin and adjacent islands: Canada Dept. of Mines, Memoir 111, No. 91, Geological Series, 1919, p. 36.

complicated, and its full discussion is reserved for another occasion. Here it must suffice to say that the trend of all the evidence—physical and stratigraphic as well as the purely faunal—now available is unmistakably opposed to the reference of the Dyer Bay dolomite of the Lake Huron region and also the in part contemporaneous Mayville dolomite in eastern Wisconsin to a pre-Niagaran age. The Mayville and Dyer Bay dolomites probably belong in the Clinton group, but they certainly are neither "Alexandrian" nor Medinan in age.

Collection.—U. S. National Museum.

CHILOBOLBINA PUNCTATA var. BREVIS n. var.

Plate XXXVII, Figs. 13, 14

Description.—Two specimens found in the vicinity of Cumberland, Md., seem too near the typical form of *C. punctata* to be satisfactorily separated as a distinct species. The specimens are preserved as casts of the interior in a sandstone, the texture of which is too coarse to show the finer details of surface markings. The features that are determinable are as in the Ontario types of the species except that the valves are relatively shorter. On the basis of this difference these Maryland specimens may be provisionally designated as above. Length, with frill, 3.0 mm.; height, 2.3 mm.

Occurrence.—CLINTON. *Mastigobolbina lata* zone of the eastern slope of Wills Mountain, near Cumberland, Md.

Collection.—Maryland Geological Survey.

CHILOBOLBINA BILLINGSI (Jones)

Plate XXXVII, Figs. 4-6

Primitia billingsi Jones, 1890, Quart. Jour. Geol. Sur., London, XLVI, p. 547, pl. xxi, fig. 10.

Description.—Average length about 2.0 mm.; height, 1.25 mm. Ends subequal, the antero-cardinal angle rectangular, the posterior angle broader. Valves rather strongly convex, highest in the ventral half, with a low curved swelling on either side of the middle along the cardinal edge;

surface punctoreticulate, with a large smoothly bordered ovate and sharply outlined median pit, two-thirds of which lies within the ventral half; midway between the pit and the base of the frill is a narrow impressed line curved so as to parallel the ventral edge. Frill concave, striated, evidently wide though imperfectly preserved in all of the specimens so far observed. Brood pouch not seen in the material from Lake Huron, the collection either containing only valves of males, or if any are female, the pouch has been broken away from the frill. That the species is a true *Chilobolbina* is clearly established by collections from the Gun River and Jupiter River formations in the island of Anticosti. The pouch in these specimens is large and higher than in *C. punctata* but not so elongate.

The identification of these specimens with *Primitia billingsi* Jones is not entirely satisfactory, the figure and description given by Jones being indefinite in various particulars. His type of the species may really belong to a species of *Apatobolbina* that is not an uncommon fossil in the Gun River and Jupiter River formations.

Compared with other species, *C. billingsi* resembles two Esthonian species, *C. dentifera* (Bonnema) and *C. kapteyni* (Bonnema) from the Ordovician Kuckers shale, more closely than it does *C. punctata* with which it is associated in both Ontario and Anticosti. However, it is not the same as either of the Esthonian species. From *C. punctata* it is distinguished at once by its more nearly equal-ended, almost symmetrical carapace, more definitely outlined and wider median pit, and the curved impressed line between the pit and the base of the frill. The low swellings along the cardinal edge also are wanting in that species.

Occurrence.—The original type came from the Gun River formation west of Jupiter River, Anticosti. The specimens now referred to the species come from both the Gun River and the Jupiter River formations. The Ontario specimens figured on Plate XXXVII were found in a green clay bed at the top of the Dyer Bay dolomite, Clay Cliffs, 2 miles west of Cabot Head, Lake Huron. Finally, a cast of the interior in sandstone found in the *Mastigobolbina lata* zone of the Middle Clinton on the eastern slope of Wills Mountain, near Cumberland, Md., agrees, so far as it goes, too closely with the Ontario and Anticosti specimens of the species to be distinguished. The same layer on Wills Mountain contains among other characteristic ostracoda of this zone also the specimens above designated as a variety of *Chilobolbina punctata*. These occurrences probably are of real significance in determining the disputed age of the Dyer Bay and Mayville dolomites of the Great Lakes region. Both of the mentioned Anticosti formations are now generally referred to the Clinton epoch.

Collection.—U. S. National Museum.

CHILOBOLBINA HARTFORDENSIS n. sp.

Plate XXXVII, Figs. 7-9

Description.—Length, without frill, 2.0 mm. or less, with frill about 2.5 mm. Shape of valves much the same as in *C. punctata* though the ventral part of the outline is not so broadly and regularly rounded. Other differences occur particularly in the median depression, which is a rather small and sharply outlined subcircular or ovate pit instead of a curved furrow. The brood pouch of the female is more elongate, with bluntly acuminate extremities and extends farther anteriorly beyond the pit. The frill is broad, slightly concave, and as usual, radially striated.

In having a median pit rather than a sulcus the species indicates alliances with the Esthonian species *C. kuckersiana* (Bonnema) and our *C. punctata*. It agrees with the former also rather well in the general outline but on closer comparison the pit proves to be larger and less rounded than in the Clinton species. Comparison with *C. punctata* shows that the outline of the valves is less symmetrical and the cardinal angles, especially the anterior, more obtuse, the pit is somewhat smaller and the ventral slope without the impressed curved line which is one of the most characteristic features of that species.

A mold of the exterior indicates that in perfect condition the surface is very minutely and closely punctate.

Occurrence.—*Mastigobolbina lata* zone, Middle Clinton, New Hartford, N. Y.

Collection.—U. S. National Museum.

Genus COELOCHILINA new genus

Proposed for the simply sulcate group of *Eurychilina* in which the node is lacking:

Genotype.—Cœlochilina (*Eurychilina*) *æqualis* Ulrich.

Range.—Stones River to Richmond groups.

The described species referred to this new genus are as follows:

Eurychilina æqualis Ulrich, Stones River (Lebanon) limestone, Central Tennessee.

Eurychilina dianthus Ruedemann, Mohawkian (Rysedorph conglomerate) New York.

Eurychilina jerseyensis Weller, Trenton limestone, New Jersey.

Eurychilina subæquata Ulrich, Black River shale, Minnesota.

Eurychilina striatomarginata (Miller), Richmond group, Ohio Valley.

Eurychilina solida Ruedemann, Mohawkian (Rysedorph conglomerate) New York.

Eurychilina oculifera Weller, Trenton linestone, New Jersey.

Eurychilina distans Krause, Ordovician drift of Northern Germany.

Genus APATOCHILINA new genus

This new genus is proposed for the Ordovician group of Eurychilinid ostracods in which both the node and sulcus of typical *Eurychilina* are wanting, the surface of the valves being more or less evenly convex.

Genotype.—Apatochilina (*Eurychilina*) *obesa* Ulrich.

The described species referred to *Apatochilina* are as follows:

Eurychilina obesa Ulrich, Black River (Lowville) limestone, High Bridge, Kentucky.

Eurychilina obliqua Ruedemann, Mohawkian (Rysedorph conglomerate) New York.

Eurychilina (*Primitia*) *plana* Krause, Ordovician drift of Northern Germany.

Genus APATOBOLBINA new genus

Eurychilinid ostracods in which the median sulcus or umbilical pit and all lobes have been submerged in a more or less evenly convex surface, agreeing thus with the Ordovician genus *Apatochilina*, from which they differ in that the female carapace develops on each valve a highly protuberant oval brood pouch which covers the post-ventral half of the frill and a considerable adjacent part of the convex area.

Genotype.—Apatobolbina granifera n. sp., basal part of Upper Clinton in Pennsylvania and Maryland and Jupiter River formation, Anticosti.

This genus stands in essentially the same relation to *Apatochilina* as *Chilobolbina* does to *Cœlochilina*. In both cases the older types differ from the younger apparently only in the fact that the females of the latter have developed brood pouches, whereas in the former females are indistinguishable from the males. The pouch in *Apatobolbina* is much like that prevailing in the Beyrichiidæ, thus being more rounded and less of it confined to the frill than in *Chilobolbina*. In the latter the pouch does not communicate with the inner part of the valves as it does in *Beyrichia*, but in *Apatobolbina* the pouch looks so much like that of *Beyrichia* and extends so far up on the slope of the ventral convexity of the valve as to suggest that in this type also it opens on the inner side of the contact margin. However, specimens retaining the pouch are as yet too few to permit determining this matter by sectioning.

Besides the genotype the genus is represented in the Gun River and Jupiter River formations in Anticosti by at least one other species. This has a more transverse carapace with produced antero-cardinal angle and longer hinge than *A. granifera*. It may be called *Apatolbolbina acuta* n. sp. The name *Apatobolbina ? appressa* is provisionally applied to a third Clinton species of which the female form has not yet been observed. The latter is figured on Plate XXXVII.

APATOBOLBINA GRANIFERA n. sp.

Plate XXXVII, Figs. 17-19

Description.—Length, with frill, 1.75 mm.; height, 1.3 mm. Valves rather strongly convex, moderately unsymmetrical highest in posterior half, oblique, the postero-cardinal angle barely distinguishable, the anterior more distinct and generally distinctly though obtusely angular; frill radially striated, moderately wide in post-ventral region, narrowing toward the cardinal angles; umbilical spot not depressed, smooth, rounded, situated a little forward and beneath middle of valve; posterior cardinal fourth with a thick undefined submarginal smooth swelling; middle and ventral slopes of valve with small and rather loosely arranged granulation. Brood pouch of female a large, very prominent oval bulb that extends upward on the post-ventral slope and downward across and beyond the edge of the frill. On our specimen it is longitudinally traversed by fine lines.

In the Jupiter River formation of Anticosti there is a variety of this species that seems to differ only in lacking the surface granulation. The same slabs contain *A. acuta* new species which also has a smooth surface and differs further in having a longer hinge line with the antero-cardinal angle slightly produced and sharply angular.

Occurrence.—The figured types of the species were found in a thin bed of limestone lying near the base of the Upper Clinton (*Mastigobolbina typus* zone), with *Mastigobolbina triplicata* (Foerste), about 2 miles west of Hollidaysburg, Pa. Typical specimens occur in zone 9 of the Jupiter River formation at Jumpers, Anticosti. Doubtfully identified valves have been observed in shaly sandstones of the *Bonnemia rudis* zone near Flintstone, Md.

Collection.—U. S. National Museum.

APATOBOLBINA (?) APPRESSA n. sp.

Plate XXXVII, Figs. 15, 16

Description.—Length, without frill, 2.0 mm.; height, 1.1 mm. In size and general outline much the same as *A. granifera,* except that the hinge is longer and the post-cardinal angle much more distinct. Besides, the surface of the valves is smoother, less convex and lacks the subcardinal swelling. The frill also is much less gently concave, being steeply inclined to the plane of the valves. Finally, the umbilical spot lies above rather than beneath the middle of the valve.

Occurrence.—CLINTON. Top of Frankstown ore seam, one-half mile northwest of Frankstown, Pa., associated with *Zygobolba rustica* and *Mastigobolbina retifera.*

Collection.—U. S. National Museum.

Family ZYGOBOLBIDAE new family

Ostracoda with more or less distinctly lobate valves, the lobes unequal in size, normally three in number, or but two, the posterior one then being obsolete, or four when the anterior lobe is divided as in the provisional subfamily Drepanellinæ; anterior and median lobes commonly united below, together forming a U-shaped ridge. Brood or ovarian pouch large, a simple, rarely bilobed submarginal swelling situated in varying places on the posterior or ventral slope.

Although most of the Ostracoda for which this new family is erected are now described for the first time, a considerable number of its species and two or three of its genera have been hitherto regarded as aberrant members of the family Beyrichiidæ. Both families doubtless originated in simple *Primitia*-like Ordovician forms, but there is nothing indicating that either was developed out of the other. On the contrary the oldest of the known species of either family is already definitely indicative of its particular family. Both families attained their most typical expression and greatest development during the Silurian period, the Zygobolbidæ in the early stages, the Beyrichiidæ in the later stages. Again, both families seem to have been almost confined during the Silurian period to the north middle Atlantic realm. Only one species of Beyrichiidæ is known in deposits of Silurian seas that invaded North America from the side of the Gulf of Mexico, and none at all in those that came in from the Arctic and Pacific sides. Of the Zygobolbidæ none is found in rocks of southern or western origin and only a few doubtful members in beds that invaded from the north.

The difference that distinguishes all of the Silurian genera of the two families lies in the form and position of the brood pouch. In the Beyrichiidæ this pouch forms a sharply inflated, small-based, prominent, ovoid bulb, situated over the small depression between the converging ventral extremities of the anterior and posterior lobes of the valves. The length of this bulb is approximately half that of the entire valve; and invariably at least two-thirds of it lies behind the middle of the ventral edge. In the Zygobolbidæ the corresponding pouch varies greatly in form and position. Commonly it appears as a mere inflation of the surface, and its base is never constricted. Sometimes, as in *Zygosella*, it takes the form of a narrow rounded ridge running parallel with and a short distance within the posterior border. At other times (*Mastigobolbina*) it makes a great swelling covering the whole of the post-ventral two-fifths of the surface. In yet other cases it is of intermediate size and lies wholly within the post-ventral quarter, as in *Zygobolba* and *Klœdenia;* more rarely it is bilobed as in *Zygobolbina.* Of course these characteristics are developed only on matured female shells.[1]

Male Zygobolbidæ are more or less readily distinguished from Beyrichiidæ of the same gender by differences in the lobation of their valves. If we compare only the typical genera of the two families, the differences in this respect are strikingly apparent. Thus, whereas in the typical Beyrichiidæ the valves are always distinctly trilobate and the posterior lobe not only well developed but commonly also nearly or quite as prominent as the anterior lobe, there is a generally notable tendency among the Zygobolbidæ to non-development or obsolescence of the posterior lobe and consequent bilobation. Moreover, the remaining lobes—the anterior and the median—nearly always join below so as to form a single U-shaped ridge. Though ventral confluence of these two lobes is often observable in Beyrichiidæ, particularly in the group of *Beyrichia buchiana,* the asymmetric position of the resulting loop imparts an aspect to the valve as a whole that could hardly be confused with that of typical Zygobolbidæ.

As will appear presently, this family is divisible into two subfamilies, the Zygobolbinæ and the Klœdeninæ, the former comprising carapaces having an emaciated appearance with narrow lobes and wide sulci, the latter more obese carapaces with relatively short narrow sulci and thick lobes and more strongly developed posterior lobes. Because of the last feature males of the Klœdeninæ often exhibit a greater degree of resemblance to the Beyrichiidæ. The lobation of certain species of *Mastigobolbina,* for instance, is much like that found in the groups of *Beyrichia salteriana* and *Beyrichia klœdeni.* Here, then, we must depend on the differences shown by their respective female carapaces. That this depen-

[1] As shells of the younger females are not distinguishable from those of the males, all specimens that are not provided with brood pouches may for descriptive purposes be designated as males. Obviously, then, the pouchless examples of most of the species are more abundant than those recognized as females.

dence is warranted is clearly shown by two facts: First, the genetic relationship of *Mastigobolbina* to *Bonnemaia* and *Zygobolba* of the deeply sulcated types, and to *Plethobolbina,* a unisulcated genus, is undeniably established by structurally and chronologically intermediate forms; second, perfectly typical species of *Beyrichia* lived in the same seas and even earlier than the oldest of the species of *Mastigobolbina* which evidently were derived out of *Plethobolbina.*

This point being established, we proceed by similar reasoning to the inclusion of other genera in the Klœdeninæ that finally diverge to points where resemblance to either Beyrichiidæ or Zygobolbidæ is but remotely suggested. Such aberrant genera are *Plethobolbina*—an early type, which may indeed indicate a survival of the simply marked *Primitia*-like root of the whole subfamily—and the later *Klœdenia* which gave rise to *Welleria* and *Kyammodes.* In *Plethobolbina* only the median sulcus is clearly developed, and this even is uncommonly short in *P. typicalis.* The posterior sulcus is undefined and in the typical species of the genus wholly wanting. But as will be pointed out more fully later on, the genetic relation of *Plethobolbina* to *Mastigobolbina* is indubitably indicated by two of its species, namely, *P. ornata* and *P. cornigera.* The former closely simulates *Mastigobolbina punctata* whereas *Plethobolbina cornigera* has features reminding of *M. glabra, M. arctilimbata,* and especially, *M. trilobata.*

Assuming derivation of *Mastigobolbina* at least, if not the whole of the Zygobolbidæ, from some early species of the type of *Plethobolbina,* the evolution of the deeply grooved and sharply ridged typical exponents of the family must have been by accelerated development of features that seem to have come out much more slowly and less definitely in the lines of *Plethobolbina ornata* and *P. cornigera.*

But these evolutional speculations are seldom firmly based on facts that may not be otherwise explained. Often we cannot be sure that some kind of reversion rather than continuously progressive evolution is responsible for the observed structural similarities. In the case under discussion the posterior sulcus in the mentioned *Mastigobolbinas* may have been tending to obsolescence, the final result being forms that, like the species *ornata* and *cornigera,* have assumed the essential characters of *Plethobolbina.* Besides, the discussion of such relations is greatly complicated by the certainty that most generic groups are variously polyphyletic in origin.

Simulating features are so often developed independently in different genetic lines that no degree of caution suffices to entirely avoid generic misassociation of genetically distinct species. Very common, too, are those simulations that are derived independently from two or more distinct species of a given genus. These divergences from type may occur either contemporaneously or at different times in the life of the genus—because of inherent tendencies in its species to vary in certain directions. Moreover, they often seem to retrace their steps so that one may be at a loss in deciding whether the stage in hand is of the progressing or the regressing series.

In the Beyrichiacea only the median pit or sulcus is constantly present and relatively stable. The other external features are less so, and the posterior lobe or ridge is the least stable. The posterior ridge may be reduced until it is lost entirely; or it may expand in width until it occupies all the space between the median lobe on the side and the outer rim of the valve on the other, the posterior sulcus then being wholly closed in the process. In the one case the reduction of the lobe is accompanied by or results in extreme emaciation of the carapace, in the other the expansion of the lobe is associated with growing obesity that finally embraces the whole of the posterior half of the carapace.

In like manner the anterior lobe may form but a narrow ridge just in front of the median sulcus, or it may expand laterally to the anterior border; in the latter condition it may be divided more or less completely by an accessory sulcus that commonly extends downward from the anterior third of the dorsal edge. But, however great the emaciation of the carapace, the anterior lobe or ridge, unlike the posterior, is never wholly effaced; and the same is true of the median ridge, for these two form the anterior and posterior boundaries of the median pit and sulcus which is always present.

In the simplest of the obese "primitian" carapaces the median sulcus defines the inner sides or slopes of areas corresponding to the anterior and median ridges of the more definitely lobed species. Besides, even in these simple forms one or the other and commonly both of these outwardly undefined ridges are distinguished from the adjacent convex surface by a low swelling node, or spine. Their permanency is more clearly indicated in the opposite extreme of emaciation. In this condition, as illustrated by most of the species of *Zygobolbina, Zygosella* and typical *Bollia,* only these two ridges remain; and because of the contrasting depression of the surface to the front and back of them, they appear as exceptionally well developed. It is in these emaciated types also that the ventral junction of the ridges which results in forming the characteristic V- or U-shaped ridge is best developed. Between its limbs lies the median sulcus.

Now all of these modifications occur and are repeated in part or whole in quite independent lines of development. Simulation in lobation and other features, therefore, may or may not indicate truly genetic relations. The final decision must take into consideration all other available features and criteria. For practical purposes the most reliable indices are those brought out by detailed comparisons of individuals, varieties, species, and genera. Apparently it is only from such hard-won data that we may finally draw reasonably valid conclusions regarding the progress of organic evolution or mutation.

Though ever tending to reproduce itself exactly no organism ever has, for this would require absolute uniformity of environment; and environment, as we know, is forever changing. The resulting effects in changing life-forms are no less though not correspondingly varied, for they are further complicated by the workings of intellect and chance.

Obviously, then, the subject of genetic relationships is always exceedingly intricate and liable to misinterpretation. For the same reasons any classification of organisms that pretends to express natural affiliations is fraught with difficulties and loaded with inadequately determined associations. To a greater or less extent, therefore, all classifications are artificial and at best only temporary makeshifts. This is true perhaps particularly of the Ostracoda. Though the framework be largely of unassailable fact, the filling is mainly of unrecognized half-truth and frank uncertainty. Things that look unlike but really are near kin are widely separated, whereas others that originated from distinct sources are associated in the same genus or family because they possess certain features wrongly supposed to be diagnostic. Mainly perhaps because of the absence of the soft parts, the fossil life history of every class of organisms is yet far from being understood; and as the only sure means of advancing toward a better understanding is by working out the intergradations of species, progress necessarily is slow and by small steps.

It is on such grounds that we have felt warranted in departing from preceding custom to the extent here illustrated by the reference of the distinctly trilobed and deeply bisulcated typical species of *Mastigobolbina* and the obesely bilobed and unisulcated species of *Plethobolbina* to adjacent positions in the same subfamily. The transitional relations between these two extremes is, we believe, clearly exhibited by species of the two genera here illustrated. By way of corroboration it may be added that even greater variation in the degree of lobation of the carapace is established by similar transitions observed in other families, notably in the Klœdenellidæ and Primitiidæ.

The genus *Klœdenia* is regarded as derived from either *Mastigobolbina* or *Plethobolbina*. If from the former, then it was brought about through the ventral obsolescence and consequent shortening of the sulci; if from the latter, it came through the development of the posterior sulcus which is wanting in *Plethobolbina*. The affinities of *Klœdenia* with the *Zygobolbidæ* are further indicated during the decadence of the family in the late Silurian by the ventral prolongation of the posterior sulcus and the consequent redevelopment of the U-shaped median ridge which distinguishes the derived *Zygobeyrichia* and at the same time recalls such preceding, early to middle Clinton species of *Mastigobolbina*, as *M. lata*, and more particularly the species of *Zygobolba*.

As stated above, the bulk of the Zygobolbidæ, as now conceived, seems to divide naturally into two subfamilies. These include all but two (*Drepanellina* and *Mesomphalus*) of the Silurian genera that seems to have any rights whatever to a place in the family. Numerically, the exceptions are of minor importance, comprising as they do only six relatively isolated Silurian species that so far have given no satisfactory clue to their genetic origin. Provisionally we may add the hitherto always troublesome Ordovician genera *Drepanella* and *Scofieldia* to these doubtful Zygobolbidæ. This association does no material violence to the general conception of the family. The only real objection is the absence in the Ordovician forms of anything like the brood pouch that characterizes the matured female examples of the more typical genera.

The genera are classified, stratigraphically located, and represented by species as follows:

Family ZYGOBOLBIDAE

Subfamily ZYGOBOLBINAE

Genus Zygobolba n. gen., Clinton, 30 + species.
Genus Zygobolbina n. gen., Lower Clinton, 4 species.
Genus Zygosella n. gen., Clinton, 10 species.
? Genus Bonnemaia n. gen., Clinton (mainly Upper Clinton), 11 species.

Subfamily KLOEDENINAE

Genus Mastigobolbina n. gen., Clinton, 21 species.
Genus Plethobolbina n. gen., Clinton, possibly also Richmond, 5 species.
Genus Klœdenia Jones and Holl, Clinton to Oriskany, 25 + species.
Genus Welleria n. gen., Tonoloway, 3 species and varieties.
Genus Kyammodes Jones, Silurian, 4 species.
Genus Zygobeyrichia Ulrich, Cayugan and Helderbergian, 10 species.
Genus Steusloffia Ulrich and Bassler, Early Silurian, 5 species.

Subfamily DREPANELLINAE (provisional)

Genus Drepanellina n. gen., Upper Clinton, 6 species.
Genus Drepanella Ulrich, Stones River to Richmond, 9 species.
Genus Scofieldia Ulrich and Bassler, Upper Black River (Decorah shale), 1 species.
Genus Mesomphalus Ulrich and Bassler, Helderbergian (Keyser member), 2 species.

Subfamily ZYGOBOLBINAE new subfamily

Genus ZYGOBOLBA new genus

Carapaces 2 to 3 mm. in length (rarely smaller), more or less obliquely subovate to elongate elliptical in outline, the figure truncated on the dorsal side by the long straight hinge. Surface of valves depressed convex lobate, with the median and anterior lobes rather well developed and surmounted by a U-shaped thin ridge or crest, the posterior arm of which commonly appears as more inflated than the anterior and ventral parts. Posterior lobe imperfectly developed, often nearly or quite obsolete; anterior lobe obscurely defined on the anterior side. Median sulcus (corresponding to the anterior sulcus of the Beyrichiidæ) deep, wide, and more or less sharply defined, commonly extending more than half across the valve; posterior sulcus usually narrow and ill-defined. Free edges of valves thick, doubly rimmed, the inner rim bordering the slight overlapping contact edges of the two valves, the outer rim or flange forming a more or less wide concave border around the anterior, ventral, and posterior sides of the exterior lobate surface of each valve. On the inner surface of the valves, hence also on casts of the interior, the flange is much less prominently developed, this being so particularly of its ventral part. In the female the brood pouch forms a large, rather well-defined, acuminate-ovate, downwardly tapering swelling. This occupies the outer two-thirds of the post-ventral quarter. Almost without exception the inflation of the posterior arm of the U-shaped crest is less than in the males. Surface of test apparently smooth or finely punctate, occasionally perhaps reticulated.

Genotype: Zygobolba (Beyrichia) decora (Billings). (See Plate XL, Figs. 11-14.)

Number of Species Known.—Thirty or more, the American species confined to formations of the Clinton group.

Generic Alliances.—The lobation and general aspect of the valves of *Zygobolba* suggest relations to *Bollia* on the one hand, and certain Beyrichiidæ on the other. The character reminding of *Bollia* is the U-shaped crest which forms the summits of the ventrally confluent anterior and median lobes. But a similarly curved and similarly located crest-like ridge is developed in certain other members of the Zygosellidæ (*e. g., Mastigobolbina incipiens*) that no one would seriously think of uniting with *Bollia.* Moreover, the union of the anterior and median lobes through confluence of their ventral portions is more or less unmistakably manifested in all of the Zygobolbidæ. It is, therefore, to be viewed as a characteristic of this family as well as of *Bollia.* Besides, it is well developed in other ostracods, as for instance the Ordovician genus *Jonesella*, which are so different in other respects that their classification in the same family even with either *Bollia* or any of the Zygosellidæ seems highly questionable. We must conclude, therefore, that the common possession of a U-shaped ridge is not of itself conclusively indicative of a closeness of genetic relationship.

Taking other features into consideration *Zygobolba* is at once distinguished from typical *Bollia* by the often feeble though yet unmistakable development of a posterior lobe. However, a more conspicuous and probably important difference is that the valves of the female carapace of *Zygobolba* and its immediate allies are provided with large brood pouches. Nothing of the kind has been observed on any of the numerous Ordovician and Silurian species of *Bollia*. It may be added that the average size of the carapace is decidedly greater in *Zygobolba* than in typical species of *Bollia*.

Compared with *Beyrichia*—excluding the groups of *B. interrupta* and *B. linnarssoni*[1] which seem more properly referable to the family Zygobolbidæ—the male carapace in the present genus is distinguished by the relatively inferior development of its posterior lobe. Also by the greater continuity and evenness and the relative narrowness of the U-shaped loop. The latter in fact suggests a structure superposed on the lobes which without it, as may be seen when casts of the interior of *Zygobolba* are compared with exteriors of *Beyrichia*, would be much less unlike in the two genera. The chief difference in lobation, aside from the disparity in their respective posterior lobes already mentioned, is that the anterior lobe in *Beyrichia* is always a more definitely outlined and more broadly prominent feature than in *Zygobolba* in which the definition of the anterior side of the lobe is commonly so obscure that its slope may be described as merging imperceptibly into the more or less wide marginal concavity. Another difference is that the indentation of the surface of the bases of the posterior and median lobes, which is as a rule clearly observable in *Beyrichia*, is wanting or but obscurely determinable in species of *Zygobolba*.

[1] Ulrich, E. O., and Bassler, R. S., Proc. U. S. Nat. Mus., vol. xxxv, pp. 295-300, 1908.

A more important difference is noted in comparing female carapaces of the two genera, namely, in the form of their respective brood pouches. Though occupying somewhat similar positions on the valves, the pouch in *Beyrichia* always is more prominent, more regularly oval, and particularly, more sharply outlined.

All of the differences mentioned as distinguishing *Zygobolba* from typical *Beyrichia* are invalidated when the comparison is extended to at least certain members of the groups of *Beyrichia interrupta* and *Beyrichia linnarssoni* (op. cit.). The species of the first group especially referred to here is the *Beyrichia damesi* Krause found in early Silurian erratics in the Baltic region. The carapace of both the male and the female forms of this species remind so strongly of *Z. williamsi* that no reasonable doubt of their congeneric relations is to be entertained. Though similar affinities are less clearly exhibited by *B. interrupta* Jones and the other two species which constitute the remainder of its group, namely, *B. granulifera* Ulrich and Bassler (*Bollia granulosa* Krause) and *B. v-scripta* (Krause) —all three of which were removed in 1908 by Ulrich and Bassler from *Bollia* to *Beyrichia*—it yet seems certain that the whole group is more truly related to *Zygobolba* and its immediate allies than to typical *Beyrichia*. Unfortunately, the female form has been observed in this group only in *B. damesi* so that we are as yet unable to decide finally that the species *interrupta*, *granulifera*, and *v-scripta* belong in *Zygobolba* and not to some other genus or subgenus of the Zygobolbidæ. Of the three the species *interrupta* seems the most likely to prove congeneric with *Z. damesi* and *Z. williamsi* and thus to belong to the genus *Zygobolba* as now understood.

The second group of *Beyrichia* above mentioned as probably more closely allied to the Zygobolbidæ than to typical *Beyrichia*, namely, the group of *B. linnarssoni* for which Ulrich and Bassler in 1908 proposed the subgeneric term *Steusloffia*, is distinguished by having one to four usually connected thin ribs coursing over the summits and sides of the lobes. Aside from these superposed ribs, the valves of *Steusloffia* resemble those of *Mastigobolbina* more than those of *Zygobolba*. In fact, pending the discovery or recognition of the female forms of the five known species of

Steusloffia, the superficial ribs afford perhaps the only really valid reason for the erection of *Mastigobolbina.*

Another rather closely simulating generic type is *Zygobeyrichia* Ulrich,[1] a genus recently established for late Silurian and early Devonian species that now seem to have been derived out of *Klœdenia* rather than *Beyrichia* as was believed before the present, more thorough studies were undertaken. Like *Zygobolba* so also is *Zygobeyrichia* distinguished from *Beyrichia* by the definitely U-shaped form of its ventrally confluent median and anterior lobes. But, as intimated above, this feature is shared by genetically very distinct ostracods. It is more or less distinctly developed in *Zygosella, Zygobolba, Zygobolbina,* and *Zygobeyrichia,* all genera of the family *Zygobolbidæ,* and equally as well or even better in such otherwise very distinct genera as *Bollia, Dizygopleura,* and *Jonesella.* In itself, therefore, the U-shaped ridge is not particularly characteristic of any of these genera.

Except in the latter three cases, which reduces our comparisons to groups of species recognized in the family Zygobolbidæ, hardly any characters of the kind and grade of importance of those hitherto employed in discriminating fossil genera of Ostracoda are available for the purpose of classifying the numerous species into clearly definable genera. The necessities of the case, therefore, demand that features hitherto neglected, also relatively small differences in others, should be promoted to a grade of importance beyond that previously credited to them. After all, the only practical means of determining the systematic value of a character is by observing its relative persistence in nature. However trivial its known biological significance, the presence of some particular character in many species that have other characters in common makes it a valuable aid in classifying organisms.

Of greater, indeed primary, importance in building any classification that pretends to a natural basis, is the determination, so far as possible, of the genetic origin and development of the objects to be classified. Therefore, giving due weight to this principle and though fully cognizant

[1] Williams, H. S., Fauna of the Chapman sandstone of Maine: U. S. Geol. Survey Prof. Paper 89, p. 290, 1917.

of the general resemblance existing between male carapaces of *Zygobolba* and *Zygobeyrichia,* we must not yield to the temptation to unite the two groups of species in one genus. They were not developed out of the same genetic roots. When *Zygobeyrichia* was proposed the belief prevailed that its species were derived from typical *Beyrichia.* This view was based on comparisons of forms having similarly well-developed lobes. However, the present more extensive investigation seems to establish beyond question that *Zygobeyrichia* was differentiated from *Klœdenia* by accentuating features initiated in species like *Z. ventricornis.* The process may be imagined as one of emaciation that brought the location of internal organs into clear relief on the outer surface of the valves. *Zygobolba,* on the other hand, was derived from some other stock—most probably *Drepanella*—at a time when real *Klœdenias* were not yet in existence.

Being convinced, then, of the genetic distinctness of *Zygobolba* and *Zygobeyrichia,* we may pass on to the consideration of possible structural differences. Critical comparisons show that even the male carapaces of the two groups of species are not entirely alike. So far as known, the anterior lobe in *Zygobeyrichia* has a broader and anteriorly fuller base than in *Zygobolba.* The dorsal part of its median lobe is also more roundly inflated and commonly more prominent. Similarly, the ventral part of the confluent median and anterior lobes is thicker, more elevated, steeper, and as a rule closer to the border of the valves. Finally, the marginal rim is narrower and flatter.

Comparisons with *Zygobolbina, Zygosella, Bonnemaia,* and *Mastigobolbina* will be found on following pages devoted to their description.

Geographic and Stratigraphic Distribution of Species.—Thirty different forms of this genus are known from American and Canadian localities in eastern North America. Many of these are described and illustrated for the first time in this work. Two or three additional forms are represented by unique specimens in collections from the Jupiter River and Gun River formations on the Island of Anticosti. Besides, as above mentioned in discussing the generic alliances, a group of four European species now referred to *Beyrichia* may belong here.

Because of its bearing on questions of stratigraphic correlation it is important to note that nine of the Appalachian species are found also in

Anticosti. Five of these are associated on the same slabs of limestone taken from the highest zone (No. 5 of Twenhofel's classification) of the Gun River formation in Anticosti, and are similarly found together on slabs of shale procured from the middle part of the Clinton as developed at Hagans, in southwestern Virginia; and four of the five were found in the "Williamson" shale member of the Lower Clinton at Rochester, N. Y. In all of these places the Ostracoda occur with numerous specimens of the same variety of *Anoplotheca hemispherica* that is one of the most characteristic brachiopods of this zone in the Appalachian region.

The stratigraphic significance of these occurrences becomes more clearly determinative when we add that the five species of *Zygobolba* common to the localities at Rochester, N. Y., and Hagans, Va., comprise all the species of the genus known from the former place. Also that only two others, or seven in all, have been found at Hagans; also that the total number of species of *Zygobolba* found in the Gun River formation in Anticosti is seven, of which four occur also at Rochester and five (including the four common to all three places) at Hagans. Finally, the collections from all of these places include specimens of certain perhaps less diagnostic species of *Paræchmina* and *Bythocypris.*

Though introducing some difficult problems of paleogeography, the direct evidence of the presence of these closely discriminated fossils seems to point indubitably to the conclusion that the beds holding them in Anticosti, New York, and southwestern Virginia are practically contemporaneous.

Z. williamsi is from the Dyer Bay dolomite in western Ontario. Williams[1] refers this dolomite to the Cataract formation but in our opinion it represents a part of the Clinton group. The other American species are all confined to beds known to be Lower Clinton in age, and most of them to localities in the Appalachian region between central Pennsylvania and the southwestern extremity of Virginia. As stated above, nine are common to the Appalachian Valley and Anticosti whereas four are known as yet only from the latter island. So far the genus is wholly unknown to the south of northeastern Tennessee.

[1] Williams, M. Y., Silurian Geology and Faunas of Ontario Peninsula, etc. Mem. 111, Geological Series 91, Geological Survey of Canada, p. 18.

Zygobolba decora (Billings)

Plate XXXIX, Figs. 15-22; Plate XL, Figs. 11-14; Plate LXIV, Figs. 21-25

Beyrichia decora and *B. venusta* Billings, 1866, Geol. Survey Canada, Cat. Silurian Fossils Anticosti, pp. 68, 69.

Description.—Length of an average carapace of the male form about 2 mm.; height of same 1.27 mm. Dimensions of largest male valve observed 2.75 mm. by 1.75 mm. Females commonly exceed males in size, the length of the largest seen about 3.10 mm.

Billings did not illustrate specimens of this species *Beyrichia decora* and *B. venusta,* nor is it known that he marked any specimens as types of them. Under the circumstances we are compelled to depend solely upon his descriptions in identifying the forms referred to by him in material collected at the same places as those from which the specimens described by Billings were procured. It should be said further that in determining which of a number of congeneric forms found together at East Cliff and The Jumpers, Anticosti, localities particularly mentioned by Billings as affording specimens of his species, is the most likely to be the same as the one mainly used by him in writing the descriptions of *B. decora* and *venusta* would be the one found in greatest abundance at the places mentioned. The selection then was made in accordance with this probability.

In studying the descriptions of *Beyrichia decora* and *B. venusta* it soon appeared that the former was founded on valves of females, the latter on those of males of the same species. At the time Billings wrote these descriptions the discrimination of the sexes in specimens of Beyricheaceæ was not appreciated as at present and as the two commonly look very unlike no particular blame attaches to Billings on account of his failure to recognize the specific identity of the two forms described by him. However, as may be seen by comparing the numerous figures, including both sexes, on Plates XXXIX and LXIV, and aside from the fact that in the mature female the brood pouch covers most of the post-ventral quarter of the valve whereas in the male this pouch is wanting, the valves in the two sexes are practically alike.

The specimens illustrated on Plates XXXIX and LXIV show not only typical examples but also the extremes of variation so far observed. The figures on Plate LXIV are reproduced from practically untouched photographs of right and left valves of seven males and two right valves of females selected almost at random from thousands of excellently preserved specimens of this species that occur on thin slabs of highly fossiliferous limestone collected at the same localities in Anticosti at which the material described by Billings was procured. The figures credited to this species on Plate XXXIX represent gutta percha squeezes of nine valves of males and three of females, right and left valves of both sexes being included. These were selected to show the variations observed among hundreds of examples preserved as molds of the exterior and interior which largely cover the bedding planes of a fine-grained ferruginous sandstone of Middle Clinton age found in southwestern Virginia. Among them we distinguish two varieties, the commoner of the two being indistinguishable from average Anticosti specimens of the species, the other a shorter-hinged form with more obtuse anterior dorsal angle. If a name is desirable for this rounder local variety it might be called variety *portalis*.

As the many figures of this species herein given show practically every feature, further description seems unnecessary. It may be well, however, to direct attention to the exceeding constancy in size, form, and details of lobation displayed by these specimens. We may add that a like degree of fidelity to type is maintained by all the other species of which many specimens have been collected. This statement, supported as it is by the testimony of photographic illustrations, is perhaps required to convince those paleontologists who have not made extensive studies of fossil Ostracoda that their separation into numerous species and the subsequent recognition of the latter is a practicable undertaking.

Occurrence.—The types of the species are from the Jupiter River formation of the Island of Anticosti. It should occur in Maryland and Pennsylvania, but so far it has been observed in the Appalachian Valley region only in the gap at Gate City, Va. Here it is found in great numbers holding a thin zone of ferruginous, soft, fine-grained sandstone occurring approximately 200 feet above the base of the formation. Associated with it are occasional specimens of other ostracoda, among them *Zygobolba arcta* and *Zygobolbina emaciata*. Also numerous specimens of

Anoplotheca subrotunda Ulrich and a small species of *Tentaculites* 10 mm. or less in length. Both of these fossils are similarly characteristic of the *Z. decora* zone, which is placed near the top of the Lower Clinton.

Collection.—U. S. National Museum.

ZYGOBOLBA ARCTA n. sp.

Plate XXXIX, Figs. 10-14

Description.—Length and height of four valves, respectively 1.8 by 1.12 mm., 1.63 by 1.09 mm., 1.62 by 1.06 mm., and 1.58 by 1.06 mm. Species based on six specimens.

This species differs but little in outline from *Z. cristata* with which it is sometimes associated, but it is readily distinguished by its much narrower border. The lobes and in fact the whole area within the border are also fuller, giving the valves a much less emaciated aspect than pertains to its more prolific contemporary. As a matter of detail it may be added that the U-shaped crest is thinner and in part less sharply defined, the ventral portion of the loop especially being inclined to obsolescence. Also that the dorsal angles are slightly more angular and the average size somewhat less than in *Z. cristata*.

Occurrence.—CLINTON. Near the boundary between the Lower and Middle Clinton (probably in both *Zygobolba decora* and *Zygobolbina emaciata* zones) at Gate City, Va., about 200 feet above the base of the Clinton and 8 miles south of Big Stone Gap, Va., it occurred about 50 feet beneath the iron ore bed in association with a larger and relatively more elongate variety. Also in the Middle Clinton (*Mastigobolbina lata* zone) at Cumberland, Md., 173 feet above the Tuscarora sandstone. So far as known the species seems very rare.

Collection.—U. S. National Museum.

ZYGOBOLBA ERECTA n. sp.

Plate XXXIX, Figs. 1-4

Description.—Length and height of the right valve of a male of average size, respectively, 2 by 1.63 mm.; of a smaller left valve, 1.75 by 1.50 mm.;

of a large left valve of the female form, 3.30 by 2.60 mm. Species based on four specimens.

Though doubtless closely related to and in some respects intermediate in character between *Z. cristata* and *Z. arcta,* this species is easily distinguished by its relatively greater height. The concave border is not as wide as and the convexity of the lobate inner area of the valves is appreciably greater than in the former whereas the opposite condition in both respects is observed when critically compared with the latter. Proportionately the height of the carapace is greater than in any other species of the genus and family. This fact, in connection with the approximate bilateral symmetry of the valves, especially those of the male form, gives them an uncommonly erect appearance.

Occurrence.—So far this species has been observed only in soft, red sandstone taken out of a tunnel in the east slope of Tussey Mountain, 1½ miles southwest of Cherrytown, Pa. The position of the bed is said by Mr. Charles Butts, the collector, to be near the base of the Clinton. A number of other Ostracoda are associated on the same piece with *Z. erecta,* among which *Z. carinifera, Z. reversa, Z. elongata,* and *Z. limbata* are likewise so far known only from this bed and locality. Evidently the zone (*Zygobolba erecta* zone) is distinct from and older than any of the Clinton ostracod zones observed in the section at Cumberland, Md.

Collection.—U. S. National Museum.

ZYGOBOLBA CARINIFERA n. sp.

Plate XXXIX, Figs. 5, 6

Description.—Length and height of a rather large right valve (male), respectively, 2.75 and 1.87 mm. Species based on five specimens.

This species is found with *Z. erecta* and evidently is closely allied to it. Males only have been seen, and these are somewhat larger than the males of that species though still inferior in size to the female. Critically compared *Z. carinifera* is found to be proportionately longer, its outline oblique, and the junction of the anterior and dorsal edges rectangular. The post-dorsal angle is more obtusely angular or narrowly rounded. The oblique form and rectangular anterior extremity of the hinge serves equally well in distinguishing the species from *Z. arcta* and *Z. cristata.* Comparison of the figures discloses other small differences.

Occurrence.—Near the base of the Clinton, on the east slope of Tussey Mountain, 1½ miles southwest of Cherrytown, Pa., where it is associated with *Z. erecta.* The species probably is abundant here as the types—comprising valves of five individuals—were all contained in 3 or 4 cubic inches of rock.

Collection.—U. S. National Museum.

ZYGOBOLBA REVERSA n. sp.

Plate XXXIX, Figs. 7-9

Description.—Length of large right valve 2.31 mm., height of same 1.34 mm.; length of rather small left valve 1.81 mm., height of same 1.12 mm. Species founded on seven specimens, all males.

The main characteristics of this species are (1) that the greatest height of the valves lies in front of the middle instead of behind, and (2) that the oblique "swing" of the outline and lobes is forward from the dorsum instead of backward. In consequence the anterior side of the carapace is likely to be taken for the posterior. As these extraordinary peculiarities have not resulted through distorting pressure, the specimens so marked must be viewed as representing a species by themselves despite the fact that in other respects they closely simulate the preceding *Z. carinifera.* However, even those features that are most nearly alike in the two forms are yet not entirely the same. Most of them differ in proportion as they are affected by not only the differences in outline and swing mentioned but also by the decidedly greater relative length of the valves of *Z. reversa.* As a matter of detail concerning their respective outlines it is worth mentioning that in *Z. reversa* the posterior part of the border is much more narrowly rounded and that the lower part of the anterior edge curves more sharply into the ventral part, whereas its straight upper part trends decidedly backward in its course to the angular extremity of the hinge. Further, it should be observed that the transverse lower part of the U-shaped crest is sharply defined also on its ventral side so that it forms a thin elevated rib along the upper edge of the wide sloping ventral part of the loop. Finally, judging from the material in hand the average dimensions of *Z. carinifera* exceed those of *Z. reversa.*

Compared with other species described on preceding pages, *Z. erecta* is found to be relatively higher, more equal-ended, and more erect in general aspect. In *Z. arcta* the border is narrower, the general form more nearly bilaterally symmetrical, and the contour of its valves more convex. The more V- than U-shaped form of the crest in *Z. cristata,* combined with the emaciated appearance of its valves and broad concave border, renders confusion with it highly improbable.

Occurrence.—Same as *Z. carinata* and *Z. erecta.*

Collection.—U. S. National Museum.

ZYGOBOLBA ELONGATA n. sp.

Plate XL, Figs. 15-17

Description.—Length of a male left valve 3.25 mm., greatest height of same 1.56 mm., length of hinge line 2.68 mm. Similar measurements of the right valve of a female gave, respectively, 3.75 and 2.03 mm. Species based on two specimens, a male and a female.

This is a large and extraordinarily elongate species, the proportionate length being greater than in any other now known. In outline the valves of the male are straight along the hinge, very greatly convex on the ventral side, with the anterior end but little narrower than the posterior; but the large pouch of the female overhangs the ventral edge sufficiently to cause its posterior half to appear considerably higher than the anterior half. Though thin, the crest is fairly distinct and sharply ridged on the exterior, but on casts of the interior, as shown in the illustrations, it is but obscurely indicated. In gutta-percha squeezes taken from the empty molds of the exterior, the anterior and median lobes and the crest are not materially different from the same parts in *Z. limbata* (see Pl. XL, Fig. 15), but the posterior lobe is thicker below, more nearly obsolete above, and more oblique in trend. The anterior lobe is thick, its anterior limits indefinite, and the slope in that direction rather gently convex. The concave border, though shallow, is fairly wide on the ends but narrow in the middle part of the ventral side. The dorsal angles are sharp but both are wider than a right angle.

The great length of its carapace and valves will at once distinguish this species from all previously described forms. Species thought to be nearer relatives are *Z. limbata, Z. buttsi, Z. parifinita,* and *Z. bimuralis.* Descriptions and comparisons with these appear on following pages.

Occurrence.—Same as the preceding *Z. carinata* and *Z. erecta.*

Collection.—U. S. National Museum.

ZYGOBOLBA PARIFINITA n. sp.

Plate XLI, Fig. 27

Description.—Length and height of the holotype, a right valve of the male form, respectively, 2.27 and 1.25 mm.; length of hinge line of same 2.20 mm.

This species, though probably inferior in size, reminds greatly of *Z. elongata* with which, besides, it is found and with which it was at first confused. Later, more careful comparison, however, convinced the authors that it is perhaps no less like *Z. pulchella*—with which, moreover, it agrees much better in dimensions—and that it represents another of the many specific modifications into which these Clinton Ostracoda are divisible. Compared with *Z. elongata* it is found to be somewhat less drawn out, the greatest height in that species being appreciably less than half the length whereas in *Z. parifinita* the length is distinctly less than twice the height. The hinge line, on the contrary, is proportionately longer in the latter, a condition resulting from its more nearly rectangular dorsal angles. Further, the two ends are even more nearly equal in size and form than are those in *Z. elongata.* When it comes to the form and disposition of the lobes, especially as they appear in casts of the interior, the two species differ in little that would not naturally follow a general reduction of the length of the carapace. The only observed exception is that the U-shaped crest is less clearly recognizable in *Z. parifinita,* the difference being in the direction of conditions prevailing in *Z. pulchella*.

Occurrence.—Same as the preceding *Z. carinata, Z. erecta,* and *Z. elongata.*

Collection.—U. S. National Museum.

ZYGOBOLBA LIMBATA n. sp.

Plate XLI, Figs. 12, 13

Description.—Length of a left valve (male) 3.34 mm., height of same 1.64 mm. Species based on five specimens.

In size and general form this species resembles *Z. elongata* but detailed comparisons show important and, in part, conspicuous differences. Of the latter the great development of the flange and concave marginal area—especially notable on the posterior end—imparts a strikingly different aspect to similar views of the two species. This may be seen by comparing Figs. 12 and 13 in Plate XLI.[1] At the anterior side the rim is more prominently and abruptly elevated and the front edge consequently more flatly thickened in views of the dorsal or ventral edges than in *Z. elongata*. The posterior lobe also differs in being narrower, less oblique, continuous to the dorsal edge, and so disposed that its rather sharp summit runs parallel with and closer to the edge of the bulbous median lobe. The posterior sulcus, therefore, differs correspondingly in being narrower and better defined in its dorsal half. Other less important differences may be noted in comparing the illustrations.

None of the other species here described seems near enough to require unusual care in distinguishing them. Only *Z. reversa,* which is found in the same pieces of sandstone and is thought to be even more truly related to *Z. limbata* than *Z. elongata,* may give any trouble. However, as *Z. reversa* commonly does not greatly exceed half the size of *Z. limbata* and

[1] The distinctness of these two illustrations is due in only small part to the fact that the former represents the *exterior* of the one whereas the latter is taken from a cast of the *interior* of the other. Interior casts of *Z. limbata* differ from reproductions of the exterior of the same individuals only in that the sharpness of the features is somewhat subdued.

proportionately is a distinctly shorter form, their separation has so far proved comparatively easy.

Occurrence.—Clinton. East slope of Tussey Mt., 1½ mi. southwest of Cherrytown, Pa.

Collection.—U. S. National Museum.

Zygobolba buttsi n. sp.

Plate XLI, Figs. 16-24

Description.—In three casts of the interior, all of males, and showing the extremes of variation observed, measurements of greatest length and height gave 1.71 by 1 mm., 1.75 by 0.98 mm., and 1.87 by 1 mm. In a testiferous left valve, preserving the wide outer border, the same measurements give 1.87 by 1.15 mm.; and in a cast of the interior of a left valve of a female 2.27 by 1.40 mm.

Ferruginous pseudomorphs of this neat species occur by the thousand, together with other Ostracoda, in a thin layer of iron ore lying about 8 feet above the main seam of the Frankstown (Pa.) ore bed. The fossiliferous ore was collected in quantity by Mr. Charles Butts, of the U. S. Geological Survey, after whom we take pleasure in naming the species. Its characters are clearly brought out by the photographic illustrations in Plate XLI. Besides indicating their essential constancy, the figures also show the strikingly different appearances of casts of the interior, on the one hand, and testiferous examples, on the other. In the latter the concave border is very wide and the lobate area within it falsely seems less convex than in the interior casts which, moreover, when freed from the matrix give no adequate indication of the actual width of the border on perfect shells.

The interior casts, in which condition all but a few of the specimens in hand are preserved, are elongate. Compared with preceding species their general form and lobation suggests affinities with *Z. elongata*, but on account of their constantly smaller dimensions one soon reaches the conclusion that the two are specifically distinct. Critically compared their ends are found to be less nearly equal in height, the anterior being not only distinctly inferior to the posterior but also different in form. Thus, whereas the posterior half of *Z. buttsi* may be justly described as a diminutive replica of the equivalent part in *Z. elongata,* the anterior half obviously is not, because (1) its height tapers forward, (2) the antero-ventral part of the outline is more gently curved, and (3) the anterior edge more nearly vertical, its junction with the hinge line forming practically a right angle. The length of the cast also is proportionately less, the height being greater than half the length, whereas it is less than half in *Z. elongata.*

When it comes to exteriors, the two species are found to be really very different. With the wide border intact, the smaller *Z. buttsi* is so much shorter and the general aspect so different that near affiliations with *Z. elongata* would scarcely be suspected. Turning to other possible allies the choice soon narrows to *Z. cristata* as the nearest known relative. In fact there is little besides the angularity of the dorsal angles to distinguish perfect specimens of *Z. buttsi* from similar examples (or corresponding gutta-percha impressions of the exterior) of *Z. cristata.* In the latter, as shown in Plate XLI, these angles are somewhat rounded or at least more obtusely angular. Among other small differences it may be observed that the curvature of the antero-ventral half of the edge of the border is more gentle and the edge itself thinner and less erect than in *Z. cristata.* Casts of the interior are more easily distinguished, those of *Z. buttsi* appearing relatively more elongate and more distinctly tapering toward the front. Such casts when left in the surrounding matrix commonly retain an impression of the inner surface of the flange (outer border) and give an idea of its width and of the extent to which it projects beyond the contact edge (see Pl. XLI, Fig. 16). Finally, the brood pouch of the female of *Z. buttsi* is more prominent, relatively larger, and its axis more nearly horizontal than in *Z. cristata.* As a rule, too, the elevation of its summit is emphasized at its widest part of a low tubercle, the like of which has not been observed in *Z. cristata.*

Occurrence.—Very abundant in a thin bed of soft, porous, fossiliferous iron ore lying about 8 feet above the main ore bed one-half mile northwest of Frankstown, Pennsylvania. The stratigraphic position of the bed seems to be not far from the top of the Lower Clinton and possibly falls into the base of the *Zygobolbina emaciata* zone of the Middle Clinton. It has not been recognized in the Clinton sections in Maryland, where, as for instance at Cumberland, it should be looked for in the hitherto apparently barren or insufficiently searched 60-foot interval between the two known ostracod beds which lie about 57 and 120 feet above the base of the formation in the sections on Wills Creek. The higher of these beds contains *Mastigobolbina lata, Zygobolbina conradi* and other species commonly found in the *M. lata* zone. The Frankstown bed is exceedingly rich in remains of Ostracoda, all of the 12 species except one so far collected from it being unknown elsewhere.

Collection.—U. S. National Museum.

ZYGOBOLBA RUSTICA n. sp.

Plate XLI, Figs. 28, 29

Description.—Length of the cast of the interior of a left valve 2.66 mm., height of same (across the median lobe, hence behind the midlength) 1.50 mm. Similar measurements of another cast of a left valve gave a length of 2.70 mm. and a height of 1.56 mm.

This species is closely allied to *Z. buttsi* and is found with it though much less abundantly. Except for its much greater size, it would be difficult to distinguish them. However, certain small differences in structure assist in assuring their distinction. Thus, the anterior dorsal angle is slightly wider, the hollow of the outer border somewhat narrower and deeper, and its edge correspondingly more erect and slightly thicker. Other differences also are to be noted in comparing the lobate areas within the border. The convexity of this is on the whole proportionately somewhat greater in *Z. rustica.* Besides, in casts of the interior, the ventral prolongation of the posterior lobe, which is otherwise similar in the two species, is commonly more distinct and the summit of the median lobe more uniformly convex in *Z. rustica.* Finally, the inner part of the anterior lobe (corresponding to the anterior arm of the U-shaped exterior crest) is thicker and never raised into a distinct ridge as commonly happens in *Z. buttsi.*

None of the other foregoing species is sufficiently like *Z. rustica* to require comparison.

Occurrence.—CLINTON. Near Frankstown, Pa., with *Z. buttsi,* which see for details.

Collection.—U. S. National Museum.

ZYGOBOLBA PULCHELLA n. sp.

Plate XLI, Figs. 25, 26

Description.—Length of a left valve of a male specimen 2.37 mm., greatest height of same 1.36 mm.

This also appears to be a close ally of *Z. buttsi,* agreeing in some respects even better with that species than does *Z. rustica.* Excepting that it is larger and the height proportionately somewhat greater, the outline is almost the same as in the former. The only other difference in outline observed in comparing casts of the interior is that the posterior edge is on the whole more nearly vertical. Judging from the remains of the border it seems to have been narrower than is the same feature on the two mentioned allies. Comparing casts of the three species, the rim, especially on the posterior side, is thicker, and the furrow between it and the contact edge shallower, in *Z. pulchella* than in the other two species. But the peculiarities chiefly relied on in differentiating *Z. pulchella* lie in the lobate area. The first of these concerns the median lobe which exhibits no suggestion of carination and is much less prominent than in the others. The anterior lobe also is less prominent and neither rigid nor particularly thickened in the part adjacent to the main sulcus. The latter, too, is shallower. Again, the post-ventrally curved lower extremity of the anterior lobe forms a low swelling beneath the median lobe that is fuller and causes a more distinct depression under the adjacent terminus of the posterior lobe than is commonly observable in either *Z. buttsi* or *Z. rustica.* Finally, the posterior lobe is less clearly defined and less prominent in its lower half but, on the contrary, as well or better developed in its dorsal extension.

Only a single valve of a female that may possibly belong to this species has been found. This, contrary to the rule prevailing in this family, is a trifle smaller than the males referred to the species. Its dimensions are approximately the same as those of the females of *Z. buttsi*, one of which is illustrated in Plate XLI, directly above the figure of the specimen under consideration. The latter, as may be seen by comparing Fig. 20 first with Fig. 18 and then with Fig. 19, agrees in size and form fairly well with the female of *Z. buttsi* but differs decidedly in its much less distinct lobes and smaller as well as more rounded brood pouch. On the other hand its characters, aside from the matter of size, are precisely such as might be expected in the female of *Z. pulchella*.

Except the allies above mentioned, and perhaps *Z. obsoleta* a discussion of which follows, no other species referred to this genus is at all likely to be confused with *Z. pulchella*. Species of two other Clinton genera, however, might sometimes give a little trouble. Thus, casts of the male form of *Mastigobolba vanuxemi* and *Zygosella vallata* occasionally resemble not only similar casts of *Z. pulchella* but also of *Z. rustica* and *Z. buttsi*. But the exteriors of these several species are so different and the form and position of the ovarian pouches in their respective females so at variance that this mere mention of possible confusion should suffice in averting it.

Occurrence.—CLINTON. Near Frankstown, Pa. Associated with *Z. buttsi*, which see for details.

Collection.—U. S. National Museum.

ZYGOBOLBA OBSOLETA n. sp.

Plate XLI, Figs. 14, 15

Description.—Of this small species only two specimens, both left valves, have been found. In one of these the length is 1.66 mm., the height 0.88 mm.; in the other similar measurements gave 1.77 mm. and 1 mm.

The size and outline, likewise the contour of the surface of the anterior half, are practically the same as in casts of the interior of the associated *Z. buttsi*. But it is not certain that these specimens are merely casts of the interior. On at least one, if not both, the marginal portions retain what seem remnants of a ferruginous pseudomorph of the test. If so, then the interior surface of the carapace must be quite different in the two species. However, waiving this point, real differences are noted in comparing their posterior and median parts. The median lobe, for instance, is practically obsolete. The posterior sulcus, and consequently the posterior lobe, are both exceedingly obscure in one of the specimens and wholly unrecognizable in the other. Obviously, therefore, the approximately even convexity of the posterior wider half of the surface looks very different from the corresponding part of the valves of *Z. buttsi*.

These peculiarities being repeated in a second specimen, the probability of the suggestion that they might be due to some abnormality in development became too remote to be longer entertained. However, there yet remains a suspicion that the described appearances are caused by some as yet unappreciated physical peculiarity of preservation.

Occurrence.—CLINTON. Near Frankstown, Pa. It is there associated with many other Ostracoda, among them *Z. buttsi,* which see for further particulars.

Collection.—U. S. National Museum.

ZYGOBOLBA WILLIAMSI n. sp.

Plate XLI, Figs. 1-9

Description.—Measurements of greatest length and height in two typical males gave, respectively, 1.50 by 0.94 mm. for the right valve, and 1.59 by 0.95 for the left valve. Similar measurements of the two right valves shown in Figs. 2 and 7, and which are to be regarded as typical female examples of the species, gave 1.52 by 1.02 mm., and 1.54 by 1.09 mm. The original of Fig. 3 is more acuminate anteriorly and uncommonly high posteriorly, therefore more triangular in outline than is the typical form. Its length is 1.62 mm., its height 1.20 mm. Figs. 4 and 5 represent two varieties both with blunter antero-dorsal angles but otherwise departing in opposite directions from the typical form, the proportionate height being considerably less in the former whereas it is greater in the latter. Length and height in the two are, respectively, 1.62 by 0.91 mm., and 1.72 by 1.25 mm.

As above indicated, the material in hand is divisible into three varieties. A great majority of the specimens are of the form designated as typical. The low, relatively elongated variety is rare but the large and proportionately short form is not uncommon. It is the last that reminds most of the previously described Anticosti species *Z. decora,* published by Billings under two names, the male form being called *Beyrichia venusta,* the female *Beyrichia decora.*

In the typical form of *Z. williamsi* the outline is dorsally truncated, acuminate-ovate, the anterior end tapering forward with a broadly convex curve beginning a short distance in advance of the middle of the ventral side and terminating at the sharply angular extremity of the straight hinge line. The ventral part of the outline is neatly rounded, the curve being somewhat accelerated as it passes into the posterior side. The posterior dorsal angle also is sharply defined but blunter than the anterior, the junction with the hinge line being a few degrees wider than a rectangle. Carried to extremes we have the form shown in Fig. 6 in which the outline has become more triangular through increased straightening of the curve in the antero-ventral third.

The form and other characters of the U-shaped crest, the slightly swollen median lobe, the small curved dorsal ridges, the border of the male carapaces, and the brood pouch of the females are all shown by the illustrations as well or better than they can be described. It will therefore suffice to point out some of the peculiarities which distinguish the species from others here described. Chiefly notable among these are the small curved ridges close to the dorsal edge. Something of this kind occurs in certain Anticosti species of the genus, like *Z. rectangula* and *Z. inflata,* but it is not so clearly developed. Still, such ridges do occur in a small early Silurian group of European species hitherto referred to *Beyrichia,* namely, the *Beyrichia interrupta* group of Ulrich and Bassler.[1]

The next important peculiarity is the acumination of the anterior end which is carried to an extreme in the typical variety of *Z. williamsi* far beyond that attained by any other species now referred to the genus. The nearest approximation in this respect is found in *Zygobolba buttsi* and *Zygobolbina emaciata* but, disregarding the distorted examples of the latter figured in Plate XLII, the differences are too obvious to cause

[1] Ulrich, E. O., and Bassler, R. S., Proc. U. S. Nat. Mus., vol. xxxv, p. 299, 1908.

difficulty in their discrimination. But this distinction does not hold good for the two varieties of *Z. williamsi* represented by Figs. 7 and 8 in which the anterior extremities are relatively blunt. The separation of these from species like *Z. buttsi* must, therefore, depend on comparison of other features.

A third peculiarity that greatly assists in distinguishing all three varieties of *Z. williamsi* from other species is the thin ridge or crest which forms the summit of the ovarian pouch of the females.

As the fourth characteristic we may count the rather general presence of small, irregularly distributed nodes on the outer slopes of the convex inner area of the valves. Their occasional apparent absence seems due to abrasion or imperfect preservation rather than to original non-development.

As above suggested near relatives of *Z. williamsi* seem to be among the members of the "group of *Beyrichia interrupta*." Of these *Beyrichia damesi* Krause,[1] an early Silurian species in the Baltic region, is the nearest of the European species. From this the present species is at once distinguished by its much more distinct border, thinner and more definitely U-shaped crest, and the in general lesser convexity of the lobate area of the valves. In consequence the valves of the American species suggest a degree of emaciation altogether wanting in its European ally.

Occurrence.—Found in great abundance in a green shale forming the top of the Dyer Bay dolomite at Clay Cliffs, about 2 miles west of Cabot Head, Ontario shore of Lake Huron, and in limestones along the southeast branch of Blanch River, north of Cobalt, Ontario. The specimens were submitted for determination by the collector, Dr. M. Y. Williams, and the species named for him in recognition of the excellent stratigraphic work being done by him in the Silurian rocks in Ontario and adjacent areas in the United States. Dr. Williams's Cabot Head collection includes four other species of Ostracoda which together are expected to have an important bearing on correlation problems now under active discussion in America.

Collection.—U. S. National Museum.

[1] Krause, Zeit. d. d. geol. Gesell., vol. xliii, 1891, p. 502, pl. 32, figs. 1-3.

ZYGOBOLBA (?) MINIMA n. sp.

Plate XLI, Figs. 10, 11

Description.—Length of left valve 1.07 mm.; height 0.70 mm. Only a few specimens of this species have been seen. These were found with remains of other Ostracoda in a thin bed of sandy shale about 57 feet above the base of the Clinton at Cumberland, Maryland. All the specimens are flattened by pressure and have their features yet further obscured by the sandy constituent of the matrix. They would scarcely be worth describing were it not that in Maryland fossils of any kind are rare in the lower 75 feet or so of the formation. In southern Pennsylvania, however, at least two if not three ostracod zones are indicated in the Lower Clinton beneath the horizon of *Mastigobolba lata,* and it was the hope of identifying one of these that persuaded the writers to work up the material from this lowest zone in the Cumberland section. Although this hope proved futile there has been some compensation in the discovery of evidence strongly indicating that the first of the Clinton deposits at Cumberland is considerably younger than are the lowest beds of the formation in certain much thicker Clinton sections in central Pennsylvania.

So far as may be determined from the material in hand *Z. minima,* though much smaller, appears to be rather closely related to *Z. williamsi.* This relation is suggested by the form of the U-shaped crest, by the characters of the border, and by faint indications of thin curved dorsal ridges. Apparently the flattening of the specimens has had no appreciable effect in the way of distorting the original outline. Assuming that the outline is still essentially normal, comparison with *Z. williamsi* shows that it is widely different. Considering the right side of the specimen, from which Figs. 9 and 10 were prepared, as posterior, it will be seen to be of less height than the anterior. Very much the opposite condition obtains in *Z. williamsi.* Even should the narrower end be the anterior, the differences in their respective outlines would still be more than obvious. But it is reasonably certain that the left half of this specimen corresponds to that part of the carapace and valves of all Zygobolbidæ and Beyrichiidæ that has been consistently and unhesitatingly recognized as the anterior. It is unmistakably indicated: (1) by the identification of the more swollen or bulbous of the two arms of the U-shaped loop as the median lobe which lies, without exception, in these families precisely as in this specimen, that is, immediately *behind* the main sulcus; (2) by the identification of the posterior lobe in the low narrow ridge that runs nearly parallel with the right-hand border and between it and the median lobe—making a posterior lobe comparable in development to that found in species of *Zygosella,* like *Z. postica, Z. mimica,* and *Z. brevis,* in which the ends are so nearly alike in outline and lobation that their discrimination is determined chiefly by the position of the brood pouch; and (3) by the fact that the sharper of the two dorsal angles, which as a rule is the anterior, is on the left side of the specimen. On these grounds, therefore, it is decided to be a left valve.

Except *Z. williamsi* no other species now referred to *Zygobolba* seems near enough to *Z. minima* to require detailed comparisons. Its relatively small size together with the pecularities in form and marking shown in the illustrations doubtless will suffice in distinguishing it.

Regarding its generic assignment some doubt must remain until female examples are discovered. These may show it to belong to *Zygosella,* the male forms of certain species of which it resembles quite as much as those of *Zygobolba.* Pending such possible discoveries it has seemed advisable to accord the greater weight to its apparent alliance with *Zygobolba williamsi.*

Occurrence.—CLINTON, in a bed of shaly sandstone lying 57 feet above the top of the underlying Tuscarora sandstone, in the section along Wills Creek at Cumberland, Md. Associated with it are *Beyrichia emaciata* n. sp. and *Plethobolbina cribraria* n. sp. As none of these species has been found elsewhere we cannot say precisely what the relations of this bed may be to the three main ostracod zones of the Lower Clinton. However, the apparent probabilities suggest that it represents a sub-zone lying somewhere between the *Z. erecta* and *Z. anticostiensis* zones.

Collection.—U. S. National Museum.

Zygobolba bimuralis n. sp.

Plate XL, Figs. 1-10

Description.—Enlarged photographs of 20 specimens, including besides the types some doubtfully referred to the species, are reproduced. All of them are separated valves, half of the number being left valves, the others right, and half, again, of males, the others of females. These figured specimens include all the variations in form and size observed on the slabs containing the types and show practically all that is known of the species. Gutta-percha impressions representing the exterior of typical males are shown in Figs. 1 and 2. Also casts of the interior of three other typical examples of the male form are shown, one of them in Fig. 4 and two in Fig. 8 which includes also casts of right and left valves of females. A typical female right valve is shown in Fig. 4.

Figure 3 is of a possible variety that can be only doubtfully referred to the species because the U-shaped crest is too thin. It probably belongs to *Zygosella mimica* and would have been referred to that species if the more characteristic females of that type had been found with it.

There is some doubt also concerning the propriety of referring all the remaining nineteen specimens to one and the same species or at least without some nomenclatural qualification. In several of the figured specimens, notably the upper and lower of the three casts included in Fig. 6, the outline differs from that of the form regarded as typical of the species. The difference occurs chiefly in the antero-dorsal quarter, the hinge line being longer and its junction with the anterior margin sharply rectangular, and sometimes even narrower, instead of rounded or obtusely angular. Such specimens, particularly the males, closely simulate *Zygobolbina conradi,* there being considerable danger of confusion between them. Females of the two, however, are more easily separated, the brood pouch being on the whole larger and much less distinctly bilobed than in *Z.*

conradi. In fact the ventral extremity of the pouch is acuminate and does not merge with the base of the median lobe. Nor is it at all clearly separated by constriction from the main part behind it.

Were perfect specimens of these difficult fossils available for study sufficient grounds for specific distinction doubtless would be found. For the present perhaps the desires of the systematist may be satisfied by distinguishing the form in question as *Zygobolba bimuralis* var. *transitans*.

The average length of the male form of *Z. bimuralis* is about 2.3 mm. Only very rarely it is as much as 2.8 mm. The female form is larger, ranging in length from 2.9 to 3.5 mm.

In its general aspect the male of the typical form reminds greatly of such good species of *Zygosella* as *Z. postica* and *Z. mimica,* but considering the widely different locations and forms of the ventral pouches of their respective females it seems unlikely that the suggested affinities can be very close. On the other hand, neither the male nor the female of *Z. bimuralis* offers any valid reason for doubting its alliance with *Zygobolba.* Removal from this genus would be justified only to the extent of placing it into the genus *Zygobolbina,* a suggestion, or incipient development, of the bilobation of the brood pouch that alone distinguishes the species of that genus being as a rule readily discernible in *Z. bimuralis.*

The incipient bilobation of the brood pouch, the very slight development of the posterior lobe, the downward tapering of the median lobe making a sag in the U-shaped crest (best seen in casts of the interior), the flattening of the higher parts of the summit of the crest, and the thick border, together with various small peculiarities in outline and surface contour give a combination of characters that cannot be readily confused with any other species of the genus. Comparisons with species of *Zygobolbina* are given on following pages.

Occurrence.—CLINTON. One hundred and seventy-three feet above the Tuscarora sandstone at Cumberland, Md. Rare associates here are *Z. arcta, Zygobolbina conradi* and its variety *latimarginata.* Other localities are Cove Gap in Tuscarora Mountain 4½ miles northwest of Mercersburg, Pa., near Warm Springs, Va., and Cumberland Gap, Tenn.

Collection.—U. S. National Museum.

ZYGOBOLBA CURTA n. sp.[1]

Plate LXIV, Figs. 1, 2, Plate LXV, Fig. 27

Description.—Characterized by the short, truncated subcircular outline, rectangular antero-dorsal angle, the rather flat border and the relatively thin lobes.

Occurrence.—CLINTON. *Zygobolba anticostiensis* zone, Hagans, Virginia, where it is associated with some of the following species.

Collection.—U. S. National Museum.

ZYGOBOLBA ANTICOSTIENSIS n. sp.

Plate LXIV, Figs. 3-7

Description.—A widely distributed and usually abundant species, with somewhat longer valves, thicker and more prominent lobes, thicker and higher rim, and deeper concave border than *Z. curta.* Also related to *Z. decora* (Billings), the most common and characteristic of the species of the overlying Jupiter River ostracod zone, but differing in its shorter form, less unequal ends, longer posterior lobe and deeper as well as longer median sulcus.

Occurrence.—GUN RIVER FORMATION. Island of Anticosti, and in corresponding beds of the Lower Clinton at Cumberland, Maryland, and Hagans, Virginia.

Collection.—U. S. National Museum.

ZYGOBOLBA EXCAVATA n. sp.

Plate LXIV, Figs. 8-13; Plate LXV, Fig. 6 (?)

Description.—The extraordinarily wide and deeply excavated border and the steepness and evenness of the anterior slope are characteristic.

[1] The following brief descriptions of species from Anticosti Island, New York, and southwestern Virginia are added partly for the sake of completeness and to show the wide geographic distribution of these fossils, but mainly because of their decisive bearing on the correlation of the Maryland formations and zones of the Clinton group with the zones of the typical Clinton in New York.

These features, together with its larger size, the more broadly curved ventral part of the loop and longer posterior lobe and sulcus distinguish the species from the associated and supposedly nearest relative *Z. anticostiensis.*

The female form of the species has not been observed unless as we strongly suspect the specimen doubtfully referred to *Z. twenhofeli* (see Pl. LXV, Fig. 6) actually belongs here.

Occurrence.—GUN RIVER FORMATION. Island of Anticosti. CLINTON. *Zygobolba anticostiensis* zone, Cumberland, Maryland, Hagans, Virginia and also in the correlated Williamson shale, at Rochester, New York.

Collection.—Maryland Geological Survey.

ZYGOBOLBA PROLIXA n. sp.

Plate LXIV, Figs. 14-17

Description.—Easily distinguished from all other species of its zone by its large size, elongate outline, projecting antero-cardinal extremity, rather thin loop, and the low and broad swelling of the anterior slope. The brood pouch of the female is uncommonly small for a species of its size and situated wholly within the base of the elevated marginal rim. The latter is thinner and narrower and the outline different from that of the similarly large and otherwise allied *Z. robusta* of the overlying *Z. decora* zone (lower part of the Jupiter River formation). Other close allies are *Z. oblonga, Z. rectangula* and *Z. twenhofeli.*

Occurrence.—CLINTON. *Zygobolba anticostiensis* zone, Hagans, Virginia, Rochester, New York (Williamson shale).

Collection.—U. S. National Museum.

ZYGOBOLBA ROBUSTA n. sp.

Plate LXIV, Figs. 18, 19

Description.—Allied to *Z. prolixa* but has higher valves, thicker and more bulbous median lobe, the anterior limb of the loop more erect, a wider border and a much deeper and wider depression between the posterior lobe and the elevated border. In some of these respects the species resembles *Z. excavata,* a Gun River species, but is readily distinguished by its larger size, more oblong shape, more convex anterior slope, and less carinate loop. Other closely related species are *Z. rectangula* which differs in outline and in having a longer loop, and *Z. twenhofeli* which has a thinner and narrower rim, more diverging loop and ventrally fuller posterior lobe.

Occurrence.—JUPITER RIVER FORMATION. Island of Anticosti.

Collection.—U. S. National Museum.

ZYGOBOLBA INTERMEDIA n. sp.

Plate LXIV, Fig. 20

Description.—This form is intermediate in most of its characters between *Z. excavata* and *Z. robusta.* However, it is somewhat shorter than either, the limbs of the loop are more nearly parallel and their passage into the connecting ventral part is more abrupt. Further, the ventral part of the outline is more convex and the anterior slope steeper and not broadly convex as in *Z. robusta.* In the latter respects it is like *Z. excavata* but the posterior lobe and sulcus are both narrower and the submarginal excavation is neither so broad nor so deep as in that species.

As *Z. intermedia* occurs associated with *Z. decora* at the two places where it has been found, collectors will be more concerned with its separation from that exceedingly abundant species than from the really closer allies with which it has been compared. In the collections now available *Z. intermedia* is much less common than *Z. decora.* The former also is a trifle larger. But the main and most constant as well as the most striking differences between them are in the shapes of their valves, the rate of divergence of the limbs of the loop and the strength and elevation of the rim. Thus in *Z. intermedia* the valves are relatively shorter and the loop longer, the limbs of the loop are more erect and subparallel and never diverge so much as in *Z. decora,* in which the loop commonly is more V-shaped than U-shaped, the ends of the valves are more nearly equal in height and the anterior end is never distinctly narrower than the posterior and the rim, especially on the ventral side, is not so thick nor so high as in *Z. decora.*

Occurrence.—JUPITER RIVER FORMATION, Island of Anticosti; CLINTON, *Zygobolba decora* zone near Alton, New York.

Collection.—U. S. National Museum.

ZYGOBOLBA RECTANGULA n. sp.

Plate LXV, Figs. 1-4

Description.—This species is characterized particularly by the length and vertical disposition of the limbs of the loop, the nearness of the base of the loop to the ventral border, the rectangular and strong antero-dorsal angle, thickness of the rim, the relatively strong inflation of the posterior limb of the loop and the unusual fulness of the ventral third of the anterior lobe. These characters will serve in distinguishing the species from *Z. robusta* in which also the depression between the posterior lobe and the elevated rim is larger. But *Z. twenhofeli* with which *Z. rectangula* is found in Anticosti is not so easily separated. The difficulty is occasioned mainly by the fact that there are two intermediate varieties one (Pl. LXV, Figs. 8, 9) having the antero-dorsal angle sharp and rectangular as in this species, whereas the other characters are as they should be in *Z. twenhofeli;* the other (Pl. LXV, Fig. 7) resembling *Z. rectangula* in the ventral reduction of the posterior lobe. In typical examples of *Z. twenhofeli* the anterior extremity of the hinge is somewhat obtusely angular, the rim is rather thin and the loop on the whole is thinner and its lower end farther removed from the ventral edge and the lower third or half of the posterior lobe further than in *T. rectangula.* The female form of the species has not been positively identified.

Occurrence.—GUN RIVER FORMATION, Island of Anticosti; WILLIAMSON SHALE. Rochester, New York; CLINTON. *Zygobolba anticostiensis* zone, Hagans, Virginia.

Collection.—U. S. National Museum.

ZYGOBOLBA TWENHOFELI n. sp.

Plate LXV, Figs. 5, 7-9 (?)

Description.—This species is approximately of the same size, associated with, and structurally most closely related to *Z. rectangula.* The two exceed in size the average for the genus and are larger than all others of the family found in Anticosti. Its recognition on slabs of Gun River limestone therefore requires unusual care only in distinguishing it from *Z. rectangula* which commonly is found with it. Typical specimens of *Z. twenhofeli* are easily separated by the relative thinness of their rims, the inferior inflation of the posterior limb of the loop and the unusual fulness of the ventral third of the posterior lobe. As a rule, too, the limbs of the loop diverge more, the anterior limb especially being less nearly vertical than in *Z. rectangula.* The loop is also somewhat shorter and its ventral extremity farther removed from the edge of the valve. Unfortunately, the slabs containing the types of the two species also exhibit occasional specimens that fail in one or more respects to maintain the normal distinctions between the two. Three of these intermediate examples are figured in Plate LXV. In one (Fig. 7) the specimen is normal for *Z. twenhofeli* in every respect except that the ventral part of the posterior lobe lacks the fulness that it should have. The other two specimens are normal in this and all other respects except that the antero-dorsal angle is too sharp thus reminding of *Z. rectangula.* However, when specimens are many and all are conscientiously compared such departures from type are to be expected.

There is considerable doubt regarding the specific relations of the valve shown in Plate LXV, Fig. 6. Instead of its belonging to a female of this species as was believed when the plates were arranged, we are now strongly inclined to refer it to *Z. excavata* instead. The anterior slope in this valve is too steep for *Z. twenhofeli* and the outline in general also compares better with that of the male of *Z. excavata* than with this species. This doubt, considered in connection with the fact that the brood pouch in *Z. prolixa* and the following *Z. oblonga* is much smaller than usual in the genus, suggests that what is above referred to as the typical form of *Z. twenhofeli* (Pl. LXV, Fig. 5), may really be the female of the first variety (Pl. LXV, Fig. 7) which in that case would be the male of the typical form. It would mean only that the disparity between the valves of the two sexes is reduced to a minimum in this species.

Occurrence.—CLINTON. *Zygobolba anticostiensis* zone, GUN RIVER FORMATION. Island of Anticosti.

Collection.—U. S. National Museum.

ZYGOBOLBA OBLONGA n. sp.

Plate LXV, Figs. 10, 11

Description.—This species is very liable to confusion with *Z. prolixa,* both being large, nearly equal in size, and similar in general expression. However, when the outline is perfectly preserved it will be found that the antero-dorsal angle is less acute and the curve on either end of the ventral edge is more abrupt, the outline on the whole therefore being more oblong and relatively shorter than in *Z. prolixa.* But there is besides another difference that is mainly relied on in distinguishing the two species. Namely, in *Z. oblonga* the posterior lobe forms a thinner, less curved ridge that, moreover, is farther removed from the posterior limb of the loop. The two limbs of the loop also do not diverge so much, the anterior limb particularly appearing as more nearly vertical than in that species. Finally, the brood pouch is even smaller, scarcely exceeding half the size of the pouch on females of *Z. prolixa.* However closely allied, the two are not the same and with a little practice may be readily distinguished.

Occurrence.—CLINTON. *Zygobolba anticostiensis* zone, Hagans, Virginia, and Cumberland, Maryland.

Collection.—U. S. National Museum.

ZYGOBOLBA INFLATA n. sp. and variety RECURVA n. var.

Plate LXV, Figs. 12-27

Description.—This is a rather variable and usually small species the characterization of which seemed the more easily accomplished by profuse photographic illustrations of specimens than by detailed description. The holotype of the species is the large left valve shown in Plate LXV, Fig. 22. This shows it to be more closely allied to *Z. rectangula* than to any of the other species described in this work. Both have rectangular antero-cardinal extremities, a long loop with only slightly diverging limbs and rather strongly inflated posterior limb, and broadly sloping anterior lobe. But the two certainly are not the same species, *Z. inflata* being constantly smaller, more delicate and emaciated in appearance, with thinner though high rim and ventrally less convex body. Longish specimens are represented by Figs. 19, 21, 24, 25 and 27; shorter examples by Figs. 12-14. Figure 26 is of the holotype of the var. *recurva* which differs from the typical form of the species in the lesser prominence of the dorsal angles. Other specimens of this variety are shown in Figs. 14-17 and 21. It should be observed also that, as is usually the case, the ridges appear thinner and sharper in the specimens that are preserved in shale than in the testiferous examples.

Occurrence.—GUN RIVER FORMATION. Island of Anticosti; CLINTON. Hagans, Virginia; WILLIAMSON SHALE, Rochester, New York.

Collection.—U. S. National Museum.

Genus ZYGOBOLBINA new genus

Beyrichia, part. and *Bollia* part. of authors.

This generic group is proposed for species conforming in general aspect, especially as regards the males, with *Zygobolba.* The only constant difference lies in the brood pouch of the female. This instead of forming a prominent and continuous semiovate or acuminate-ovate swelling covering the outer two-thirds of the post-ventral quarter of the valves, is unequally bilobed, the ventral part, which looks like a continuation of the post-median lobe, being more or less completely divided from the larger posterior part by prolongation of the posterior sulcus. The valves of the female carapace therefore have a distinctly different appearance from those of *Zygobolba.*

Genotype.—*Zygobolbina conradi* n. sp.

Only four species and one good variety having the required kind of brood pouch in combination with the lobation of the carapace prevailing in *Zygobolba* are as yet known. Of these the genotype, along with its variety *latimarginata* and *Z. emaciata,* occur in Middle Clinton zones. The other two, *Z. carinata* and *Z. panda* are from the Frankstown ore bed in central Pennsylvania. The stratigraphic position of this bed is not certainly determined. It may lie either a little above or beneath the boundary between the Lower and Middle Clinton.

ZYGOBOLBINA CONRADI n. sp.

Plate XLIII, Figs. 1-11

Description.—Length 2.6 mm.; height, 1.75 mm. This is a rather large clearly defined species, the outline somewhat oblique but varying in this respect, the hinge straight, terminating at distinct angles, the anterior side dropping off vertically, the posterior outline more rounded, the ventral side broadly convex. The U-shaped ridge is thick and prominent, usually with a descending prolongation below that connects it with the strong marginal rim; the dorsal halves of its limbs project slightly beyond the hinge line and are slightly swollen this being so especially of the posterior limb. The posterior lobe is practically obsolete. Usually the females are larger than the males. The brood pouch is divided as it should be by prolongation of the posterior sulcus into a moderately prominent ovoid post-ventral lobe and a smaller swelling that looks like a ventral continuation of the posterior limb of the U-shaped ridge. The specimens found at Gate City, Virginia and at Armuchee, Georgia, are smaller than the average for the species as found at localities in Maryland, Pennsylvania and New York. In other respects, however, there is no appreciable difference.

Valves of this species were figured and included with the same species as *Mastigobolbina* (*Agnostus*) *lata* by Hall in 1852. More recently Ulrich and Bassler having observed that Hall had included two quite distinct ostracods under the name "lata" provisionally referred to the second as *Bollia lata.* The facts in the case are fully discussed under our remarks on *Mastigobolbina lata* to which the reader is referred. Here it suffices to say that because of confusion likely to result from a second and altogether different usage of the term *lata* in this connection we have decided to propose the new name above employed.

Occurrence.—CLINTON. New Hartford, New York, localities in Pennsylvania, Cumberland, Maryland (120 feet above the Tuscarora sandstone), Gate City, Virginia, and Armuchee, Georgia. At most localities it is associated with *Mastigobolbina lata* and other species that like it seem to be confined to the zone to which the latter name has been applied.

Collection.—U. S. National Museum.

ZYGOBOLBINA CONRADI LATIMARGINATA n. var.

Plate XLIII, Figs. 12-19; Plate XLII, Fig. 1

Description.—The average size is somewhat greater in this variety than in typical *Z. conradi*. Besides there are various small but constant differences in structural details that probably would have warranted full specific separation. Of these differences the most striking and perhaps important is the greater width and deeper excavation of the hollow anterior and posterior borders. However, this feature is very notable only in molds of the exterior (*e. g.*, Pl. XLII, Fig. 1). On casts of the interior the height and extent of the border is not fully indicated so that these commonly resemble typical *Z. conradi* in greater degree. The outline, further, is relatively longer and more oblong, and the curve in the post-ventral part sharper and more produced. Finally, the U-shaped ridge is somewhat thinner and less prominent.

Occurrence.—Associated with and nearly as abundant as the typical form of the species at most of the localities in New York, Pennsylvania, Maryland and Virginia where the latter has been found. The best specimens were collected at New Hartford, New York, Reedsville, Pennsylvania and Cumberland, Maryland (120 feet above the Tuscarora sandstone). Two casts of the interior of left valves found in the Frankstown ore bed are doubtfully referred to this variety. The specimens are imperfect at their margins and in the absence of their counterparts in the matrix which would give us a more satisfactory conception of the outer surface of their shells it is impossible to decide positively whether they belong to this variety or not.

Collection.—U. S. National Museum.

ZYGOBOLBINA PANDA n. sp.

Plate XLIII, Figs. 20-22

Description.—Length 2.6 mm.; height, 2.0 mm. This species is characterized by its relatively short form, wide and rather shallow, undefined concave border and thin rather low but sharply crested U-shaped ridge. These features distinguish it, at once from *Z. conradi* which may be designated as its nearest relative. It certainly is farther removed from both *Z. conradi latimarginata* and *Z. emaciata.* The valves of the following *Z. carinata* with which it is associated at Frankstown, Pennsylvania, resemble it in that the U-shaped ridge is sharply crested but differs so greatly in its outline, erect border and much better developed posterior lobe that confusion between them seems quite unlikely.

Occurrence.—In the Frankstown ore bed, which lies near or at the top of the Lower Clinton one-half mile northwest of Frankstown, Pennsylvania. It is associated here with other species of ostracoda described in this volume.

Collection.—U. S. National Museum.

ZYGOBOLBINA CARINATA n. sp.

Plate XLII, Figs. 11-20

Description.—Length 2.6 mm.; height, 1.75 mm. Somewhat smaller than *Z. conradi* which it resembles in general outline though not exactly, its two ends more nearly equal. On critical comparison, however, it is found to differ in many respects. In the first place the posterior lobe is better developed in the male than in that or any other species now referred to the genus. Next, the U-shaped ridge is much thinner and surmounted by a thin crest of which no sign has been observed in *Z. conradi.* Something like this crest occurs in the associated *Z. panda* but that species differs so decidedly in other respects that further comparison between them is unnecessary. Another peculiarity of this species is the relative minuteness of the anterior division of the brood pouch. The larger division also differs from that of the other species of the genus in seemingly involving the whole of the posterior lobe in its swelling.

Many specimens of the species are before us. Each looks more or less different from the other, the variations depending upon the state of preservation. The more striking of these apparent differences are shown by the nine valves—five left valves, four right—figured on Plate XLII. The different appearances result from varying degrees in which the shell is wanting. In most of them the thin and highly elevated border is at least partly broken away. Three of them retain considerable parts of it. In most of the others the shell is wanting completely and only one retains the greater part. The last shows the crested character of the lobes.

Occurrence.—Frankstone ore bed, at or near the top of the Lower Clinton, one-half mile northwest of Frankstown, Pennsylvania.

Collection.—U. S. National Museum.

ZYGOBOLBINA EMACIATA n. sp.

Plate XLII, Figs. 2-10

Description.—Length, 2.75 mm.; height, 2.00 mm. Apparently a close ally of *Z. conradi* but easily distinguished by its thinner U-shaped ridge and generally more emaciated appearance. Separated valves occur in great abundance on certain bedding planes rather low in the Middle Clinton near the tollgate on the Cove Gap road from Mercersburg to McConnelsburg, Pennsylvania. Unfortunately the outline in nearly all of these specimens is more or less distorted by horizontal compression of the rock. As shown by the illustrations some are shortened, others lengthened, relatively, with every conceivable variation in form according to the ever varying angle at which the direction of pressure crossed the valves. The original form of the valves must have been something almost exactly between that of Figs. 2 or 6 on the one hand and Fig. 3 on the other. Accordingly, the outline must have been more oblique and the posterior end relatively wider than in typical *Z. conradi.*

Occurrence.—Lower part of Middle Clinton (*Zygobolbina emaciata* zone), near tollgate, Cove Gap, Tuscarora Mountain, 4½ miles northwest of Mercersburg, Pennsylvania. Also at Gate City and near Big Stone Gap, Va., and Cumberland, Md. Specimens doubtfully referred to the species occur in the Frankstown ore bed near the top of the Lower Clinton, one-half mile northwest of Frankstown, Pa., and in the *Zygobolba erecta* zone of the Lower Clinton, 1½ miles southeast of Cherrytown, Pa.

Collection.—Maryland Geological Survey, U. S. National Museum.

Genus ZYGOSELLA new genus

The carapace of the male is essentially the same as in *Zygobolba* and *Zygobolbina,* but that of the female differs in the shape and position of the brood pouch. This forms a narrow ridge-like elevation lying on or closely paralleling the posterior border which it follows from the dorsal to the ventral edge. The posterior limb of the U-shaped lobe is always the straighter and more nearly vertical of the two, and it is by this means that the almost equal-ended valves may be determined as the right or left as the case may be.

Genotype.—*Zygosella vallata* n. sp.

Nine species and one variety of the genotype are known of this generic type. All occur in the Clinton deposits of the Appalachian region and all are described and illustrated in this volume. *Z. vallata* and its variety, *nodifera, Z. alta, Z. macra,* and *Z. cristata* occur in the lower half of the Upper Clinton; the others are found in various beds of the Middle Clinton.

In general aspect the valves of the males in this genus closely resemble those of species of *Bollia.* However, in *Bollia,* so far as known, the sexes are not distinguishable by characters showing on the exterior surface of the carapace. In *Zygosella,* on the contrary, the two sexes are conspicuously differentiated by the long and narrowly crescentic brood pouch on the posterior edge of the valves in the female form.

Zygosella is divisible into two groups, the one including *Z. vallata* n. sp. with one variety, *nodifera, Z. alta, Z. macra* n. sp., and *Z. cristata,* the other comprising *Z. postica* n. sp., *Z. gracilis* n. sp., *Z. limula* n. sp., *Z. mimica* n. sp., and *Z. brevis* n. sp. The two groups differ structurally in the form and width of the brood pouch, this feature being thinner and dorsally more incurved in the former than in the latter group. The two sets of species also hold different stratigraphic ranges, the *Z. vallata* group so far having been found only in Upper Clinton zones whereas the group of *Z. postica* seems to be confined to Middle Clinton zones. Finally, the species of the older group are all smaller than those of the younger *Z. vallata* group.

ZYGOSELLA VALLATA n. sp.

Plate XLV, Figs. 1-3

Description.—Length, 3.00 mm.; height, 1.5 mm. In this species the two limbs of the V-shaped ridge are keeled and diverge considerably in dorsal direction, the outline is distinctly narrower in front than behind, the border is high, broad, and thick, and the median parts of the valves are largely sunken beneath its level. Casts of the interior which often retain little indicating the height and width of the flange-like border may look quite different from the exterior of the perfect shell. In these the V-shaped ridge also is much less prominent than on the outside of the valve, the slightly bulbous posterior limb alone standing out as a conspicuous elevation. The brood pouch forms a thin, narrow ridge on the inner slope of the raised border. As it nears the dorsal edge it curves forward until it approaches or quite reaches the dorsal extremity of the posterior limb of the yoke.

Occurrence.—Lower part of Upper Clinton. Though perfect valves of this species are not easily procurable it must yet be regarded as one of the most common and widely distributed ostracoda of the *Mastigobolbina typus* zone. It has been found at Great Cacapon, W. Va., where it occurs about 29 feet beneath the Keefer sandstone. Also at Six Mile House and Stone Cabin Gap, Md., Hollidaysburg, Pa., Williamsville, Va., and other places where its zone has been searched for fossils.

Collection.—U. S. National Museum.

ZYGOSELLA VALLATA NODIFERA n. var.

Plate XLV, Figs. 7-10

Description.—Approximately of the same size as the typical form of the species, from which it differs mainly in having two or three small nodes on, but near the base of, the inner slope of the anterior ridge. Of other small differences that may be observed on critical comparison of the illustrations it may be pointed out (1) that the limbs of the U-shaped ridge diverge in lesser degree, (2) that the brood pouch of the female is thinner, and (3) the dorsal angles are sharper than in the typical form of the species.

As this form seems to be confined to a lower zone than that in which typical *Z. vallata* is found and its peculiarities appear to be reasonably constant, we would perhaps have been warranted in describing it as a distinct species. However, we feel convinced of its ancestral relations to *Z. vallata* and for this reason believe it provisionally advisable to adopt the above classification.

Occurrence.—CLINTON. *Bonnemaia rudis* zone, near Six Mile House, Md., where it was found about 120 feet beneath the Keefer sandstone and at Williamsville, Va. Also with millions of *Bonnemaia rudis* at Mulberry Gap, Powell Mountain, 5 miles northwest of Sneedville, Tenn.

Collection.—U. S. National Museum.

ZYGOSELLA ALTA n. sp.

Plate XLV, Fig. 11

Description.—Length (male valve), 2.75 mm.; height, 1.75 mm. This species attains somewhat greater dimensions than any of its congeners. It was found with *Z. vallata nodifera*, with which it agrees in having two or three small nodes on the anterior slope of the depressed space between the limbs of the U-shaped ridge. However, in other respects the two forms are widely different. In fact the present species differs notably from all of its allies in the greater convexity of its valves and more prominent crested ridges. The posterior lobe, especially in the female, also is better developed than in other species excepting perhaps *Z. macra*. Further, the outline is more nearly elliptical and equal-ended and the border more erect and steeper on its inner slope. The brood pouch is thicker than in *Z. vallata* and its variety, this feature again being more as in *Z. macra*. After all, however, the characteristic that will be found the most serviceable in recognizing *Z. alta* is the uncommonly great thickness of its carapace.

Occurrence.—So far found only at Big Stone Gap in southwestern Virginia and on Powell Mountain (5 miles northwest of Sneedville) in northeastern Tennessee. At both places it is associated with *Bonnemaia rudis* less than 50 feet beneath the more or less eroded top of the Clinton. In this part of the Appalachian Valley the overlying *Mastigobolbina typus* zone commonly is either wanting entirely or retained only in part. The Keefer sandstone may be represented in a few places, but the *Drepanellina clarki* zone probably never so far down the valley.

Collection.—U. S. National Museum.

ZYGOSELLA MACRA n. sp.

Plate XLV, Figs. 1, 4-6

Description.—Length (female), 3.1 mm.; height, 2.00 mm. This species is easily distinguished from *Z. vallata,* with which it occurs, by its slightly larger average size, more equal ends, the anterior being relatively higher, much less diverging limbs of the U-shaped ridge, more convex median areas and thinner border, the former appearing less sunken beneath the level of the latter. Further, the lowly convex areas on either side of the U-shaped ridge are fuller and the posterior one is wider. In most of these respects the species agrees better with *Z. alta,* but the maximum thickness of the carapace and valves is considerably less than in that species and the space between the limbs of the yoke much narrower. Moreover, the border does not rise so steeply as in that species. Finally, so far as observed, there are no such nodes on the anterior slope of the median sulcus as in *Z. alta* and *Z. vallata nodifera.*

Occurrence.—CLINTON. Found in considerable abundance associated on the same slabs with *Z. vallata* and *Mastigobolbina typus* at Williamsville, Va. Doubtless it occurs in this zone (*M. typus* zone) also in Maryland.

Collection.—U. S. National Museum.

ZYGOSELLA CRISTATA n. sp.

Plate XLV, Figs. 12-14.

Description.—Length, 2.5 mm.; height, 1.6 mm. This is a rare fossil but when found may be distinguished at once by its rather low but angular ridges and relatively short form. The ends are more unequal in height and the posterior half relatively higher than in any other species of its group. The limbs of the yoke diverge very slightly and are not very prominent, but the median areas generally are quite as convex as in *Z. macra.* The border is wide and broadly hollowed, particularly on the posterior side. But the feature on which we mainly rely in distinguishing the species from others of its group is the curved angulation or ridging of the surface of the incipiently developed posterior lobe. This low ridge joins the posterior limb of the yoke and between them outline a gently concave semi-elliptical space.

Occurrence.—CLINTON (*Mastigobolbina typus* zone), 29 feet beneath the Keefer sandstone, near Six Mile House, Md.

Collection.—Maryland Geological Survey.

ZYGOSELLA POSTICA n. sp.

Plate XLIV, Figs. 1-10

Description.—Length, 2.4 mm.; height, 1.4 mm. The males of this, like the other species of its group, might readily be mistaken for a species of *Bollia.* The outline is slightly oblique, the upper two-thirds of the posterior side sloping backward to a point where the outline turns rapidly forward into the broadly yet distinctly convex ventral side. On the anterior side the most prominent point is above the midheight. The U-shaped ridge is well formed and clearly defined, its posterior limb more nearly vertical and less curved than the anterior limb. The dorsal extremities are rather obtusely angular though clearly indicated, the rim is thick, moderately high and clearly defined. The brood pouch suggests an added ridge somewhat thicker and longer than the limbs of the median yoke. It extends upward to the post-dorsal angle from which its longitudinal axis trends with slight anterior curve to and slightly beyond the post-ventral edge.

There is practically no danger of confusion between this and any of the previously described species. The disparity in size alone would prevent it.

Occurrence.—CLINTON. *Zygosella postica* zone, at Narrows, Va., Cumberland, Md., and other localities exposing its zone. Identified also from the *Zygobolbina emaciata* zone at Cove Gap, 4½ miles northwest of Mercersburg, Pa.

Collection.—U. S. National Museum.

ZYGOSELLA GRACILIS n. sp.

Plate XLIV, Figs. 11-14

Description.—Length, 2.75 mm.; height, 1.5 mm. This is associated with *Z. postica* at Narrows, Va., and was at first mistaken for its young. but closer examination revealed larger specimens and sufficient structural differences to soon establish its distinctness. The male valves always are more elongate, that is, comparing specimens of equal length the height in these is quite obviously less than in those. The ventral side of the outline also is straighter or rather less convex. In the female the axis of the brood pouch is more diagonal with respect to the long axis of the valve. It is also straighter and more sharply angulated on its inner side.

Occurrence.—CLINTON. New River, 1 mile west of Narrows, Va. (*Zygosella postica* zone) and at Cove Gap, Tuscarora Mt., 4½ miles northwest of Mercersburg, Pa. (*Zygosella emaciata* zone).

Collection.—U. S. National Museum.

ZYGOSELLA BREVIS n. sp.

Plate XLIV, Figs. 21-25

Description.—Length, 2.4 mm.; height, 1.6 mm. This doubtless is closely allied to *Z. postica* though showing decided relations also to the following *Z. mimica* and *Z. limula.* Its outline is relatively shorter than in any of these and the convex curve of the ventral part is more pronounced. It is a rare fossil at all places except Cove Gap, Pa., where, however, all the fossils in the beds containing it have suffered more or less distortion by rock pressure. The supposed original outline is retained by a single right valve found at Cumberland, Md., on a bedding plane showing thousands of individuals of *Zygobolba bimuralis*. In this as in the Cove Gap specimens the posterior lobe is barely indicated by a low and narrow ridge lying close to the base of the posterior limb of the U-shaped ridge. It is more clearly indicated than in *Z. postica* but not so well as in *Z. limula* and *Z. mimica.*

Occurrence.—CLINTON. *Zygobolbina emaciata* zone near the tollgate in Cove Gap of Tuscarora Mountain, 4½ miles northwest of Mercersburg, Pa. A specimen occurring with *Zygobolba bimuralis* probably comes from a different though nearby zone at Cumberland, Md.

Collection.—U. S. National Museum.

ZYGOSELLA MIMICA n. sp.

Plate XLIV, Figs. 18-20

Description.—Length, 2.25 mm.; height, 1.37 mm. Another ally of *Z. postica* from which it differs in its outline, this being less oblique and less convex in the ventral part. On the whole, too, the form is relatively a little shorter or higher. A more important difference, visible, however, only in the males, is the much stronger and more definite development of the posterior lobe. This lobe is more strongly indicated than in any other species of the genus. In the female the brood pouch is larger than in *Z. postica* and its axis, except in its basal incurved and projecting part, almost perfectly vertical. The rim is well developed though not so thick as in *Z. postica.*

The next following species, *Z. limula,* probably is a closer relative of *Z. mimica* than the one with which we have compared it.

Occurrence.—CLINTON. *Mastigobolbina lata* zone, Gap, 1½ miles northwest of Warm Springs, Va.

Collection.—U. S. National Museum.

ZYGOSELLA LIMULA n. sp.

Plate XLIV, Figs. 15-17

Description.—Length, 2.5 mm.; height, 1.5 mm. The specimens referred to under this designation indicate a species that seems more closely related to *Z. mimica* than to any of the others now known. However, it is distinguished readily enough from that species by its more ovate outline and more deeply and more broadly excavated border. In these features it reminds of *Z. alta* and *Z. macra,* but its dimensions are far inferior to either of those later species, whereas the thickness of its carapace is relatively much less than in the former and the excavation of the surface of the valves outside of the U-shaped ridge is much greater than in *Z. macra.* The brood pouch is of the type prevailing in the group of *Z. postica* and not like that marking the group of *Z. vallata.*

Occurrence.—CLINTON (*Zygobolbina emaciata* zone), Cove Gap, 4½ miles northwest of Mercersburg, Pa.

Collection.—U. S. National Museum.

Genus BONNEMAIA new genus

Very large Zygobolbinæ, commonly 4.0 to 6.0 mm. in length, the U-shaped ridge thick, its posterior limb often divided in its upper half by a short posterior sulcus, the anterior lobe usually crowned with a more or less sigmoidally curved angular crest. The development of the posterior lobe varies greatly in different species. In some, as in *B. obliqua* and *B. perlonga,* it is wanting entirely; in others, *B. celsa* for example, it is represented almost solely by a short spur trending downward from the post-dorsal quarter of the elevated border, or as in *B. rudis* and *B. longa,* by a barely perceptible elevation in the wide depression of the surface between the post-median lobe and the posterior part of the border. In yet others, like *B. crassa* and *B. oblonga,* it is present in full width in the convex inner area of the valves, leaving only a relatively narrow, deep excavation between it and the posterior border, but in these cases the lobe is only partly or indefinitely separated from the post-median lobe. Finally, as in *B. fissa* and *B. transita,* the posterior lobe is rather well developed and clearly defined on its inner side by deepening and extension of the posterior sulcus to a length nearly equalling that of the larger and always well-developed median sulcus. Brood pouch essentially as in *Zygobolba.*

Genotype.—Bonnemaia celsa n. sp.

With the exception of *B. notha,* which was found in the *Mastigobolbina lata* zone of the middle Clinton, all the species referred to this genus are confined to the lower and middle parts—*Bonnemaia rudis* and *Mastigobolbina typus* zones, respectively—of the Upper Clinton. All of the eleven species and two varieties are new and described for the first time. So far the genus has been observed only in the Appalachian region, in which it ranges southward from Clinton, in central New York, through Pennsylvania, Maryland, West Virginia and southwestern Virginia into northeastern Tennessee. In this narrow but long area one or more of its species abounds at every locality that exposes the particular beds of the Clinton in which they occur. The several species therefore are to be counted among the most valuable of guide fossils. It is an interesting fact, the significance of which is not fully understood, that not a single specimen of this genus or indeed any member of its family has rewarded careful search in supposedly contemporaneous Red Mountain Clinton deposits in Alabama. The probable explanation of this absence is that the Upper Clinton of Pennsylvania and Maryland is not represented by marine deposits in that State.

The naming of this interesting and for various reasons highly important new genus after Dr. J. H. Bonnema of the University of Groningen is intended as a manifestation of our high regard for the quality of his work on Paleozoic ostracods of the Baltic region. As to differences of opinion between us regarding the proper orientation of the valves of Beyrichiaceæ we can only regret that they still exist.[1]

[1] The argument advanced by us in 1908 in our Revision of the Beyrichiidæ in support of our contention respecting the determination of which of the two valves is the right and which the left, or as to which end of the carapace is the anterior and which the posterior, seems no less valid to-day than then. Our argument was founded primarily on a natural assumption regarding the position of the brood pouch of the female in certain genera and deductions

The relations, systematic and genetic, of *Bonnemaia* to other genera are involved and difficult to express in words. Probably we can make no better start of the discussion than by stating our conviction that *Bonnemaia* is a possibly composite culminating expression of one or more closely originating subparallel lines of contemporary development out of species of *Zygobolba.* The genus thrived at a time when, and in a sea wherein other groups of the family, to wit, *Mastigobolbina* and *Plethobolbina,* also assumed larger proportions and developed certain features in common. Among the latter is the sigmoidally curved crest of the anterior lobe in *Bonnemaia* which is the homologue of the "whip-lash" of the Upper Clinton species of *Mastigobolbina* and *Plethobolbina cornigera.* But the curving of the crest commonly fails to reach the stage attained by the "whip-lash" and in some does not proceed beyond the stage reached by such of the Middle Clinton species of *Mastigobolbina* as *M. lata.* Another tendency, variously expressed in *Bonnemaia* but followed in common though along wholly separate paths with the last group *Mastigobol-*

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based on correlations of corresponding parts in genera and species in which the two sexes are not similarly distinguished but some of which have an unquestionable eye spot that proves the anteriority of the end containing it. Regarding the pouch we held that it must be posterior in position and not anterior as it would be if Dr. Bonnema's view were the correct one.

In the course of the present investigations we have discovered and asserted the feminine sex of such pouch-bearing individuals of many different kinds of ostracoda. Indeed, we found these pouches to be among the most reliable of generic characters and have therefore made extensive use of them in the systematic classification of the species. They occur in almost perfectly simple forms, like *Apatobolbina,* as well as in the complexly lobed types of which pouched individuals have been known a long time. In this connection it is important to note the fact that their position on the valves is maintained with gratifying constancy not only within the limits of each species, but also throughout the confines of large genera. Of yet greater significance is the fact established by thousands of observations that the whole or at least the greater part of the pouch lies in every instance to one and the same side of the middle of the valve; and this side is the one that on other grounds we have regarded as the posterior.

If this pouch has anything whatever to do with the generation or rearing of the young it is hardly conceivable that it could be developed on the anterior border or side of the valve. Yet this would have to be so for *Zygosella* and *Mastigobolbina,* in both of which it lies wholly within that half of the carapace that according to Dr. Bonnema's view would be the anterior.

bina, namely the group of *M. trilobata,* is the expansion of the lobes at the expense of the sulci and marginal furrow. One phase of this thickening of the lobes is shown in *B. transita,* other in *B. oblonga, B. crassa,* and *B. perlonga.*

That the species of *Bonnemaia* were derived out of *Zygobolba* and probably, at least in part, separately—meaning by this that the genus comprises the terminals of two or more subparallel lines of descent and not merely the rapidly established subdivisions of a single branch—is suggested by various facts. In the first place little argument is required to show the reasonable probability of the asserted development of *B. notha* out of *Zygobolba.* Aside from the considerable size of this species, a fact that helped materially in deciding our reference of it to *Bonnemaia* instead of *Zygobolba,* we need only to direct the attention of the reader to the similarities in structure that it exhibits to several fairly typical species of the latter genus. These are most clearly indicated by comparison of interior casts. Compare, for instance, the three casts—right and left male and a right female valve—shown in Fig. 7 on Plate XLVIII with similar casts of *Z. buttsi* figured on Plate XLII, and those of *Z. bimuralis* given on Plate XLI. In essentials the lobing of the valves is practically the same in the interior casts of these three species. The features requiring particular emphasis in this connection are the elongate elliptical outline of the post-median lobe and the ventral decline or sagging of the summit of its neck-like lower extremity before it joins the ventral part of the U-shaped loop. But all the lobes are thicker in *B. notha* than in the species of *Zygobolba* with which we are comparing it; and therein lies the main reason for our conclusion that *B. notha* represents an early and possibly the first recognizable though as yet incompletely established introduction of the *Bonnemaia* type of structure developed out of a *Zygobotba* like those mentioned. Other reasons for the adopted generic assignment of *B. notha* are given in the specific discussion.

The next step in the evolution of *B. notha* might very well be that which we have called *B. obtiqua.* At about the same time its line may have split to give rise to a form like *B. transita grandis;* and by departure in somewhat different directions it may have produced forms like *B. oblonga* or even *B. crassa.* But species like *B. rudis, B. fissa,* and *B. pulchella* seem to us as having rooted in other species of *Zygobolba* than the one out of which *B. notha* was developed.

The relations to *Mastigobolbina,* which may seem clear enough when we take into consideration mainly such forms as *B. fissa* and *B. transita,* are in fact much less clear than they appear at first. It was this first impression that suggested the latter name for the species that seemed most clearly to indicate some kind of transition from the more typical species of *Bonnemaia* to those of *Mastigobolbina.* In fact, that first impression was so strong that if of the considerable group of species that we have brought together under the generic term *Bonnemaia* all the others had remained undiscovered, we would have experienced no misgivings in referring the species *transita* without question to *Mastigobolbina.* However, the discovery of these other species disclosed alliances that without them could not have been suspected. With them we reach a point where we are almost ready to deny that the apparently close relations of *B. transita* to certain of the known species of *Mastigobolbina* are in any wise direct or orthogenetic.

Taking only such typical species of *Mastigobolbina* and *Bonnemaia,* as *M. typus, M. arguta,* and *M. intermedia* and *B. celsa, B. rudis, B. longa,* and *B. oblonga,* none could doubt the absolute generic distinctness of both the male and female forms of the two types. But we distinguish and refer to *Mastigobolbina* no less than 23 species and named varieties and to *Bonnemaia* 11 species and 2 varieties. Naturally these numbers include, particularly among the earlier ones, a few too many species of each that differ more or less decidedly from their respective genotypes; and among these again there are some that judged empirically would probably be given a different generic position from that assigned to them by us. *B. transita* may be cited as one of such species. The only difference of possibly generic significance between it and such a species of *Mastigobolbina* as *M. trilobata,* or even *M. triplicata,* is the relative shortness of the sulci, especially the posterior one. In all species referred to *Mastigobolbina* the posterior lobe, whether narrow or wide, is a persistent feature and the posterior sulcus is sharply defined and long and either divides the posterior lobe completely from the confluent bases of the median and anterior lobes or it leaves only a narrow ventral contact with the other lobes. In species of *Bonnemaia,* on the contrary, the posterior lobe varies greatly in development. In some species (*e. g., B. obliqua* and *B. perlonga*) it is quite obsolete; in others only its middle and lower parts are wanting (*e. g., B. celsa*); in yet others it is obsolete and the posterior sulcus, if it is distinguishable at all, never extends as a well-impressed furrow beyond the mid-height of the valve. In two otherwise very different species, namely, *B. pulchella* and *B. oblonga,* a very shallow continuation of the sulcus extends downward to or slightly beyond the lower extremity of the median sulcus.

In deciding the generic assignments in the several instances we have been guided, of course, primarily by the characters of the specimens. But in a considerable number of cases this basis alone failed to lead to satisfactory conclusions. In these then we depended mainly on obvious or more or less probable genetic alliances as indicated by detailed comparisons of particular and general characters. Thus, for instance, in determining the generic position of *B. transita, B. pulchella,* and *B. fissa*—the first of which reminds in general aspect of species of *Mastigobolbina* like *M. trilobata,* the second in some respects of species like *M. declivis* and *M. lata,* in others like *M. intermedia,* the third also of species like *M. intermedia*—we found that each could be brought by transitional forms into closer relations to typical species of *Bonnemaia* than to the species of *Mastigobolbina* with which they might otherwise have been associated.

The closeness of the relations of *B. transita* to *B. pulchella* and of the latter to *B. celsa,* the genotype of *Bonnemaia,* will, we believe, be appreciated at once. It is indicated not only by similarity in general aspect but also by comparison of details of the lobing of their respective valves. At least it must be admitted that the relations between the mentioned three species are more conclusively indicative of actually genetic affiliations than are those that suggest alliance of *B. transita* and *B. pulchella* with *Mastigobolbina trilobata* and *M. declivis,* respectively.

In like manner we find that the simulation of *Bonnemaia fissa* and *Mastigobolbina intermedia* is more apparent than genetically real. The flattening of the surface of the lobes that obtains in the former but not at all in the latter is a feature more commonly pertaining to species of *Bonnemaia* than of *Mastigobolbina.* In the latter genus it is markedly developed only in *M. lata* and *M. declivis*—both of them rather untypical species—whereas in *Bonnemaia* it is well developed in *B. celsa, B. crassa, B. longa,* and *B. oblonga* besides *B. fissa.* Then one has only to try to separate many specimens of *B. fissa* and *B. rudis,* the latter an unquestionable *Bonnemaia,* to realize that these two species are congeneric and in fact more closely allied than one may think from comparison of figures only. In other directions also the generic alliance of *B. fissa* with more typical species of *Bonnemaia* is clear. Compare it, for instance, with *B. longa* figured on the same plate and with *B. oblonga* on Plate XLVIII.

Finally, as regards *B. pulchella,* we are thoroughly convinced that its simulation of *M. declivis* and *M. trilobata* is to be viewed as a relatively fortuitous family resemblance rather than as indicating true genetic relations and that it is overbalanced in systematic significance by the resemblance it bears to so typical a species of *Bonnemaia* as *B. longa.*

BONNEMAIA CELSA n. sp.

Plate XLVI, Figs. 1-6

Description.—Length, 3.5 mm.; height, 2.4 mm.; greatest thickness (through anterior edge of anterior lobe), 1.4 mm. Outline slightly oblique, the posterior half usually a little wider than the anterior, the hinge straight but rather short, the dorsal outline more or less broken by projecting lobes, the cardinal extremities obtusely angular, the ends and ventral side distinctly convex; border thick and high. The median sulcus is deep, rather narrow and extends half across the valves. The U-shaped median lobe is thick, obliquely flat-topped, very high and angular on the anterior side which drops off abruptly into the depression between it and the elevated border. This depression is widest near the middle of the posterior half and above its widest part is constricted by a vertical spur-like projection from the inner side of the elevated border.

This spur represents the sole remnant of the posterior lobe of Beyrichiaceæ. The sharp-edged summit of the anterior lobe makes a broad anterior curve —somewhat more sharply arcuate than the anterior outline—but as it nears the dorsal edge the direction of the curve is reversed so that the ridge here points directly across the transverse axis. The resulting slightly sigmoid crest represents the flagellum of *Mastigobolbina*.

The nearest allies of this species are *B. crassa* and *B. obliqua,* which see for comparisons.

Occurrence.—CLINTON. *Mastigobolbina typus* zone, Flintstone, Md., 32 feet beneath base of Keefer sandstone; Cumberland, Six Mile House, and Stone Cabin Gap, Md., 1½ miles east of Great Cacapon, W. Va., where it is found 23 feet beneath the Keefer; also at Williamsville and Big Stone Gap, Virginia.

Collection.—Maryland Geological Survey, U. S. National Museum.

BONNEMAIA CRASSA n. sp.

Plate XLVI, Figs. 7-9, and Plate XLVIII, Fig. 19 (?)

Description.—Length of average specimen, 3.0 mm.; height, 2.0 mm.; greatest thickness of single valve, 1.15 mm. A close ally of *B. celsa* with which it is associated but readily distinguished by its smaller size and structural differences. The general outline and border are much the same in the two species, but the lobed inner area is so extensive in *B. crassa* that it leaves relatively a much narrower depressed zone between it and the border. The posterior ridge instead of forming a mere spur on the border is joined to the median swelling from which it is partly separated by a sharply defined short cleft in the post-dorsal quarter. The median sulcus is a trifle shorter, appears more oblique and flares more, especially on the posterior side, as it opens on the dorsal edge. Finally, the anterior lobe, though thick and high, lacks the sharp crest which bounds its anterior side in *B. celsa.* In consequence the surface of the anterior lobe lacks also the characteristic flatly sloping top. The difference in the latter respects are clearly notable in comparing ventral views of the two species (*e. g.,* Pl. XLVI, Figs. 5 and 9). Of the following species *B. oblonga* may be classified as intermediate between *B. crassa* and *B. celsa.*

It has the crested anterior lobe of the latter but in all other respects agrees better with the former.

The specimen represented by Fig. 19 on Plate XLVIII is doubtfully referred to this species. It is unusually large and in some of its features suggests *B. oblonga* rather than *B. crassa.* Such a feature is the crest on the anterior lobe, but this is not prominent enough for either *B. oblonga* or *B. celsa.* The ventral three-fifths of the posterior lobe also is somewhat thick and thus reminds of *B. oblonga.* But the complete coalescence of this part with the lower half of the median lobe points so obviously to *B. crassa* that taken in connection with the other similarly trending features we cannot deny its close and probably conspecific relations to *B. crassa.*

Occurrence.—CLINTON. (*Mastigobolbina typus* zone), 23 feet beneath Keefer sandstone, 1½ miles east of Great Cacapon, W. Va., and at Stone Cabin Gap, and Cumberland, Md.; also at Big Stone Gap, Va.

Collection.—Maryland Geological Survey.

BONNEMAIA OBLONGA n. sp.

Plate XLVIII, Figs. 14-18

Description.—Length of average left valve of male of typical form (Figs. 14 and 15), 3.9 mm.; height of same, 2.5 mm. The female is larger, attaining a length of 4.75 mm. The outline is more oblong, less equal-ended, and less convex on the ventral side than in *B. crassa* and *B. celsa,* both of which—the former, however, much more than the latter—resemble *B. oblonga* in the characters of the lobed inner area. Compared more critically with *B. crassa* the present species is found to differ in several parts of the lobed area. The anterior lobe, for instance, is more distinctly carinated—somewhat as in *B. celsa,* only not so prominently. The lower part of the median lobe also is more clearly indicated and defined by a shallow depression from the posterior lobe, the lower half of which forms a rather prominent and wide swelling or plateau even in the male. In the female the shallow depression mentioned is largely obscured by encroachment of the brood pouch. The median lobe is somewhat irregularly pyriform in outline, the irregularity being mainly in the middle part of the posterior side where the deeply impressed dorsal half of the posterior sulcus ceases and thence passes into its shallower ventral continuation.

The outline of the valves of *B. oblonga* is not greatly different from that prevailing in *B. obliqua,* but, as is pointed out in discussing that species, the bases of the lobes are broader than in that species. Other rather close allies are *B. transita, B. fissa,* and *B. longa.*

Occurrence.—CLINTON (*Mastigobolbina typus* zone), 29 feet beneath Keefer Sandstone, Sir Johns Run, Md., one mile southeast of Big Stone Gap, Va.

Collection.—Maryland Geological Survey.

BONNEMAIA OBLIQUA n. sp.

Plate XLVI, Figs. 10-15

Description.—Length, 4.75 mm.; greatest height, 3.25 mm. The outline in this species is somewhat obliquely oblong and usually not materially different from that commonly found in *B. oblonga,* which may be set down as its closest known ally. There is, however, a tendency to increase both the degree of obliquity and the inequality in height of the ends over the average in these respects observed in that species. As a rule therefore the post-ventral quarter of the outline is slightly more produced in *B. obliqua* than in *B. oblonga.*

However, more constant and also more important differences are found in comparing the lobes of the two species. To begin with, the ventrally confluent lobes are not so broadly based so that the depressed or rather the concave area lying between their summits and the base of the elevated margin is wider than in that species. Further, there is no clearly defined posterior sulcus and consequently no convex part of the surface that may be confidently correlated with the rather well-developed posterior lobe of *B. oblonga.* Finally, the median sulcus is narrower and more nearly parallel-sided, and the median lobe is correspondingly more erect. In fact, its axis intersects the hinge line at practically a right angle. Because of these distinctions profiles of the valves of the two species are notably different. Other close allies are *B. fissa* and *B. longa.*

Occurrence.—CLINTON. *Bonnemaia rudis* zone at Mulberry Gap, Powell Mt., 5 miles northwest of Sneedville, Tenn., Wills Creek, Cumberland, Md., and state line east of Rickard Mt., Williamsport quadrangle, Md.

Collection.—U. S. National Museum.

BONNEMAIA FISSA n. sp.

Plate XLVII, Figs. 7-9

Description.—Length of average male, 3.0 mm.; height, 2.12 mm. This is a smaller species than *B. oblonga, B. obliqua, B. transita,* and *B. rudis,* to each of which it exhibits close alliance in one or another respect. It agrees with the first in having a well-defined deep posterior sulcus, but this sulcus is longer than in that species, extending nearly as far across the valves as does the median one. The general outline also is much the same in the two, though the ventral edge commonly is less convex in *B. oblonga* than in the present species. Even more striking differences are noted in comparing the lobes. In *B. oblonga* these have such wide bases that they occupy a much greater proportion of the area lying within the elevated border. In *B. fissa* the lobes are relatively much thinner and the angular crest of the anterior lobe curves more strongly forward as it turns upward from its ventral part and then recurves so as to make a distinct sinus in its course to the dorsal edge. Further, the lower half of the posterior lobe is much narrower and the depressed area behind it much wider than in *B. oblonga.* In view of these many and in part conspicuous differences it seems quite unlikely that anyone will experience much trouble in separating these two species. Valves of their females are similarly and on the whole hardly less different than the males.

The main lobes are as narrow in *B. obliqua* as in *B. fissa,* but the lack of anything like a well-developed posterior lobe or a posterior sulcus in the former is a sufficiently striking difference to distinguish the two at a glance. Detailed comparisons of course reveal other differences.

Discriminating comparisons with *B. rudis, B. transita,* and *B. pulchella* will be found on following pages devoted particularly to their several discussions.

Occurrence.—CLINTON. *Bonnemaia rudis* zone, Mulberry Gap, Powell Mt., 5 miles northwest of Sneedville, Tenn.

Collection.—U. S. National Museum.

BONNEMAIA RUDIS n. sp.

Plate XLVII, Figs. 1-6

Description.—Length, 3.5 mm.; height, 2.6 mm. The male valves of this species remind somewhat of *B. celsa,* on the one hand, and *B. fissa* on the other. They are distinguished from the former at once by their much thinner and less prominent lobes and correspondingly wider and longer median sulcus. The constancy of these differences is attested by comparisons of many specimens of each and the fact that none of either suggests any sort of transition between them. The exceeding abundance of specimens of *B. rudis* is clearly indicated by the small part of a slab shown in Fig. 5.

B. fissa occurs less abundantly on the same slabs with *B. rudis.* The separation of the two is not always easily accomplished for the reason that their respective peculiarities often are obscured by breakage or imperfect separation of the interior casts from their exterior molds. The matrix is a soft sandstone and the space formerly occupied by the shell itself is now filled with a more or less rotted ferruginous pseudomorph. Therefore, in splitting the slabs the plane of cleavage may pass through or along either the inner or outer surface of the filling. When clean and perfect molds of the exterior are available and good impressions of these have been made in gutta percha or clay the difficulties of accurate separation of the two species have been largely overcome. Comparison of such impressions (see Plate XLVII, Figs. 1 and 3 on the one hand and 7 and 9 on the other) shows that the main structural difference between the two lies in the fact that whereas in *B. fissa* both the posterior sulcus and the posterior ridge are clearly defined and uncommonly well developed for the genus neither is clearly indicated in *B. rudis.* Moreover, in the latter the lobes commonly show irregularities suggesting a rough unfinished appearance that is quite foreign to the more neatly constructed

B. fissa. As a rule, too, the height of the valves in the present species is relatively greater, the lobes are more prominent and more convex and without the notable flattening of their summits and the sharpness of their sides that pertains to *B. fissa.* Finally, the average size of the males is appreciably greater than in that species.

B. rudis is related also to *B. obliqua* but never attains the size of that species. This together with obvious differences in their respective outlines and in the position of the anterior lobe with respect to the anterior edge of the valve makes the task of separating these two species uncommonly easy.

Occurrence.—CLINTON. *Bonnemaia rudis* zone, Mulberry Gap, Powell Mt., 5 miles northwest of Sneedville, Tenn., and at Big Stone Gap, Va.

Collection.—U. S. National Museum.

BONNEMAIA PULCHELLA n. sp.

Plate XLVIII, Figs. 1-4

Description.—Dimensions of the holotype, a right valve: length, 3.5 mm.; greatest height, 2.5 mm. The valves in this neat species are shorter and, except on the straight dorsal side, more rounded in outline than in any other species of the genus. The cardinal angles are sharp and slightly produced, the sigmoid crest of the anterior lobe is well defined and hooks forward as it approaches the dorsal edge, the anterior slope is gently convex but on the whole descends steeply, the border is wide and clearly defined, the depression within it distinct, narrow on the anterior and ventral sides and much wider but not so sharply defined on the posterior side. The median sulcus is deep, rather long and of moderate width, the post-median lobe is prominently convex, elliptical in outline, narrowing distinctly in its ventral part, the posterior sulcus just behind it is a shallow, the posterior ridge low, not well defined in the middle of its straight posterior side but more clearly limited below and again above where it joins the elevated border which here curves forward toward the dorsal extremity of the post-median lobe, passing well within the produced dorsal angle.

This species doubtless is closely allied to *B. transita* and perhaps less intimately also to *B. fissa*. As all three of these species often occur associated on the same slabs some care is required in distinguishing them. *B. pulchella* differs from the other two in its more rounded outline and more prominent dorsal angles. Further comparison with *B. transita* will be found in following descriptive notes on that species. Regarding its relations to *B. fissa* we may add here that the outline is not only more rounded but the height is relatively much greater and the height of the two halves more nearly equal. A more important difference concerns the posterior sulcus which is much deeper and better defined in that species but ceases abruptly before attaining the length of the median sulcus. In *B. pulchella,* on the contrary, it extends in its characteristically shallow manner to beyond the terminus of the median sulcus. Further, the surface of the lobes is less convex in that species and the course of the crest of the anterior lobe is materially different. Namely, in *B. fissa* it does not form a sigmoid curve, the dorsal half of its extent being almost straight. Moreover, the lower curve of the crest occurs farther down and is sharper.

B. rudis also is associated with this species and like it has uncommonly short valves. Still the two are so different in other respects that, providing good specimens are at hand, confusion between them seems altogether unlikely.

Occurrence.—CLINTON. *Bonnemaia rudis* zone, Wills Creek, Cumberland, Md. Somewhat smaller specimens were found in the same zone in Mulberry Gap, Powell Mountain, 5 miles northwest of Sneedville, Tenn. At this place the *B. rudis* zone lies at the top of the Clinton section.

Collection.—U. S. National Museum.

BONNEMAIA TRANSITA n. sp.

Typical variety, Plate XLVIII, Figs. 8-11; var. *grandis,* Plate XLVIII, Figs. 12, 13; var. *transversa,* Plate XLVII, Fig. 13

Description.—Length of right valve of typical form, 2.5 mm.; greatest height of same, 1.75 mm.; length of another right valve of typical form in which the height of the anterior and posterior halves is more nearly equal, 2.6 mm.; greatest height of same, 1.75 mm.; length of left valve of var. *transversa,* 3.13 mm.; height of same, 1.75 mm.; length and height of a right valve of var. *grandis,* 4.6 mm. and 3.13 mm., respectively.

We distinguish three forms of this species. First the typical form represented by Fig. 9. With it we include some slightly longer specimens like Fig. 10. The latter approaches the var. *transversa* in which the length is relatively greater, the anterior part of the outline less convex and the median sulcus somewhat wider than in the typical variety. The third variety, for which the subordinate designation *grandis* is provisionally proposed, occurs in a higher zone than the others. It differs from them in its much greater size, narrower posterior sulcus, wider post-median lobe and the higher position of the anteriorly curved part of the crest of the anterior lobe. If these peculiarities prove reasonably constant it would be well to raise its rank to that of a distinct species.

In the following discussion the references to *B. transita* are mainly concerned with the typical variety of the species.

The close relations of this species to *B. pulchella* was mentioned in the preceding description of that species. As a rule the valves of the present species are smaller than those. Their height also is proportionally inferior. However, the difference mainly relied on in distinguishing the two lies in the posterior lobe as developed in males. In *B. transita,* namely, the posterior lobe is more definitely separated from the post-median lobe, this being brought about by greater depth of the posterior sulcus. Moreover, the posterior lobe is thicker, especially in its lower half, is more clearly defined on its posterior side, and occupies much more of the space between the post-median lobe and the elevated posterior border. Besides, it extends through to the dorsal edge and does not, as in *B. pulchella,* join the elevated border at some considerable distance beneath the dorsal edge. In consequence of these facts the furrow between the posterior lobe and the elevated border is not only narrower and deeper but extends as a narrowing channel quite to the dorsal edge. Finally, the posterior dorsal angle is not produced, as in *B. pulchella,* beyond the incurving post-dorsal extension of the elevated border. In all other respects the two species are practically the same.

In certain features *B. transita* occupies an intermediate position between *B. oblonga* and *B. fissa.* This is true particularly of the relative development of the posterior sulcus. In *B. transita* this sulcus is moderately deep and nearly as long as the median sulcus, in *B. fissa* it is deeper and, because of the flattened tops of the adjoining lobes, its sides are sharper. In *B. oblonga,* on the other hand, this sulcus is moderately deep only in its upper third, the middle and lower parts, the latter of which, moreover, extends beyond the lower end of the median sulcus, being very shallow. On further comparison with *B. oblonga* we find that the outlines of the valves of *B. transita* are more rounded, the hinge-line being shorter, the dorsal angles less prominent, and the border around the ventral half more uniformly curved. Further, the surface of the lobes is more convex with scarcely a suggestion of the broad flattening of their summits that pertains to *B. oblonga.* The course of the crest of the anterior lobe also is decidedly more curved, while the furrow between the posterior lobe and the border is not only less sharply defined and shallower but also it runs through above to the dorsal edge instead of being cut off as in *B. oblonga* by confluence of the posterior lobe with the elevated border. Various other differences may be observed in critical comparisons of figures of the two species.

The female forms of *B. fissa* and *B. pulchella* have not been recognized. Hence, comparisons of these with that of *B. transita* cannot as yet be made. The pouch of the female regarded as belonging to *B. transita* presents the almost unknown feature in both *Bonnemaia* and *Mastigobolbina* of failing to extend outwardly across the border. A narrow groove divides its outer limits from the top of the elevated border. The pouch forms a large depressed hemispheric inflation of the posterior half of the valve, reaching well up toward the dorsal angle, though falling short of it, and looking so that it is liable to be mistaken for a large posterior lobe. A similar brood pouch has been observed only in the otherwise peculiar species to which we have applied the name *Mastigobolbina ? bifida.* Though widely different in other respects it is of interest to note that the two species in which this kind of pouch occurs are associated in the same bed in northeast Tennessee.

Further comparisons with *B. fissa* might be desirable only because it is found in the same zone. However, the differences between them, particularly as regards the form and details of structure of the lobes and furrows, are so clearly indicated in the illustrations on Plates XLVII and XLVIII that they are believed unnecessary.

As stated in the preceding generic discussion this species was given the name *transita* because it seems to us to combine in a marked degree the characters of *Bonnemaia* and *Mastigobolbina.* In that discussion we have set forth the reasons that induced us to refer it and certain other species to *Bonnemaia* rather than *Mastigobolbina.*

Occurrence.—CLINTON. The typical variety is found rather abundantly in the *Bonnemaia rudis* zone in Mulberry Gap of Powell Mountain, 5 miles northwest of Sneedville, Tenn. The variety *transvera* occurs in the same bed and place but seems a rarer fossil. The variety *grandis* was found associated with *B. oblonga* in the *Mastigobolbina typus* zone of the upper Clinton, 29 feet beneath the Keefer sandstone at Sir Johns Run (Devils Nose), Md.

Collection.—U. S. National Museum.

BONNEMAIA LONGA n. sp.

Plate XLVII, Figs. 10 and 11, 12 (?)

Description.—Dimensions of holotype, a right male valve: Length, 4.13 mm.; height, 2.5 mm. Good exteriors of the male form show that this is a well-marked and fairly typical species of *Bonnemaia* with rather close though not very obvious relations to *B. celsa* and *B. obliqua* on the one hand and *B. perlonga* on the other. Compared with *B. celsa* the outline of the valves is so distinctly more elongate and more nearly equal-ended that one sets them apart on the first casual glance. This conclusion is substantiated when further comparison discloses many other differences, among them the more decidedly sigmoid course of the angular crest of the anterior lobe. This crest, namely, turns rather sharply forward as it nears the dorsal edge and more broadly though even farther forward in the opposite—ventral—direction; and it is nearly or quite as high and the surface descends in anterior direction no less abruptly than in *B. celsa.* In fact, the anterior slope of this lobe is more concave than in that species. The posterior sulcus and lobe are both very imperfectly developed. Even the spur-like projection from the dorsal quarter of the posterior border that constitutes the main representative of the posterior lobe in *B. celsa* is practically absent in *B. longa.*

B. longa is farther removed from *B. obliqua* in which the posterior half of the valves is relatively much higher and the outline on the whole therefore much more oblique. The lobes in that species also are narrower, the median sulcus is correspondingly wider and the concave spaces of the surface both fore and aft of the lobes are more depressed and usually appear wider.

The relations to *B. perlonga* are discussed in the following notes on that species. The real types of *B. longa* were found along Wills Creek in the city of Cumberland, Md. A few specimens of the same or a but slightly different form were observed in the *B. celsa* zone on Powell Mountain near Sneedville, Tenn. Two of these, a male and a female, are included in the small part of the surface of a slab shown in quadruple magnification on Plate XLVII, Fig. 5. Unfortunately, none of these Tennessee specimens show the exterior surface so that we cannot decide positively whether they are strictly conspecific with the Maryland types of the species or not.

Other specimens that may belong to this species were found in a higher zone of the Upper Clinton at Sir Johns Run, Md. These, too, we regret to say, are not in satisfactory condition, the valves being more or less distorted and crushed in the shaly matrix. One of these specimens—the left valve of a female—is shown on Plate XLVII, Figs. 11 and 12. These figures differ enough from that of the holotype, Fig. 10, the right valve of a male, to warrant hesitancy in declaring their specific identity. Indeed, the apparent tenuity of the rim and certain peculiarities about the median and posterior sulci suggest the possibility that the Sir Johns Run specimens represent quite a different species.

Occurrence.—CLINTON. The typical specimens are from the *Bonnemaia rudis* zone along Wills Creek in Cumberland, Md. Specimens doubtfully referred to the species occur in the same zone on Powell Mt. 5 miles northwest of Sneedville, Tenn., and also in the upper Clinton at Sir Johns Run, one mile west of Stone Cabin Gap, Md., and Williamsville, Va.

Collection.—U. S. National Museum.

BONNEMAIA PERLONGA n. sp.

Plate XLVI, Figs. 16-18

Description.—Length of typical male left valve, 5.25 mm.; greatest height of same, 2.62 mm. The most striking of the peculiarities of this species is the extraordinary length of the carapace that has suggested the specific name *perlonga.* Otherwise it is comparable with the preceding *B. longa* without, however, being strictly like that species in any respect. Critically compared with the typical form of *B. longa* (see Plate XLVII, Fig. 10) the elevated border in the present form is thicker, the post-median lobe also is thicker and shorter and its dorsal extremity more rounded, and both the median sulcus and the crescentic posterior depressed area are wider. Another important difference is in the course and position of the angular crest of the anterior lobe. The sigmoid curvature of the crest is similar in the two species, but whereas in *B. longa* its dorsal part maintains a median position with respect to the anterior and posterior sides of the lobe in *B. perlonga* on the contrary it turns so far backward that it forms the precipitous dorsal third or more of the anterior boundary of the median sulcus.

None of the other species now referred to this genus is sufficiently like *B. perlonga* to require detailed comparison.

Occurrence.—CLINTON. (*Mastigobolbina typus* zone) 1 mile west of Stone Cabin Gap, Bear Pond Mountains, Williamsport quadrangle, Md., and one mile west of Narrows, Va.

Collection.—U. S. National Museum.

BONNEMAIA NOTHA n. sp.

Plate XLVIII, Figs. 5-7

Description.—Length of a left valve, 3.0 mm.; greatest height of same, 2.0 mm. A larger valve, retaining all of the upturned thin border but otherwise like the preceding specimen, has a length of 3.25 mm. and height of 2.25 mm. This species differs from all of the preceding species of the genus in the greater segregation and relative prominence of the post-median lobe. This is notable mainly in casts of the interior. These resemble interior casts of *Zygobolba* and *Zygobolbina* in which also the ventrally confluent parts of the lobes seem abnormally low or at least are not so clearly separated from the border (compare Plate XLIII, Fig. 9, and Plate XL, Figs. 8, 9, 16, and 17 with Plate XLVIII, Fig. 7). The females of the species agree further with those of *Zygobolba* in the form and low position of the brood pouch. However, this fact has little significance in determining the generic relations of *B. notha* because the brood pouch in all of the unquestionable species of *Bonnemaia* of which the female is known holds a similarly low position and differs from that of *Zygobolba* only in its inferior convexity and prominence. (Compare Plate XLVII, Figs. 4 and 6 with Plate XL, Figs. 5, 6, and 8.)

We have referred *B. notha* to *Bonnemaia* because of general and particular resemblances it bears to such other less doubtful species of the genus as *B. obliqua*. The rather notably great thickness of the anterior lobe indicates this genus and not *Zygobolba*. However, we miss the curved angular crest that is so commonly found on this lobe in *Bonnemaia*. The border, however, though wide enough, is thinner than usual in this genus. On the other hand, the post-median lobe is broad and defined behind by a short though narrow posterior sulcus so that the whole of the post-dorsal quarter is sufficiently like the same quarter in such, in part typical, species of *Bonnemaia* as *B. transita grandis*, *B. crassa*, and *B. oblonga* to encourage the conviction that *B. notha* is at least nearer the genus in which we have placed it than it is like any other now recognized.

The features mentioned together with the fact that its valves are much larger than those of any known species of either *Zygobolba* or *Zygobolbina* will probably suffice in distinguishing *B. notha* from species of those genera. The fact that *B. notha* occurs in a lower zone than the other species of *Bonnemaia* and also that its zone holds many species of Zygobolbinæ may explain its synthetic combination of characters. At the same time these facts tend to substantiate our conviction that *Bonnemaia* is the culminating expression of the Zygobolbinæ and not, as some of its species may suggest, an aberrant member of the Klœdeninæ.

Occurrence.—CLINTON. *Mastigobolbina lata* zone, Gate City Gap, Va.

Collection.—U. S. National Museum.

Subfamily KLŒDENINAE new subfamily

Genus MASTIGOBOLBINA new genus

Rather large trilobate Zygobolbidæ, typically with a narrow posterior lobe, a much larger and irregularly shaped anterior lobe and a pyriform median lobe, the latter tapering below and passing into a whip-lash-like raised extension (the "flagellum") that turns obliquely forward and upward and then backward again across the anterior lobe. From these typical species, constituting the group of *M. typus,* we pass by easy gradations (1) to the group of *M. trilobata* in which the posterior lobe is large and broadly convex like the anterior lobe and the flagellum tends to become entirely obsolete; (2) to the group of *M. lata* in which the flagellum is either obsolete or more commonly forms a merely angular gently curved crest on the anterior side of the anterior lobe; (3) to the group of *M. incipiens* in which the anterior and posterior lobes are wide (as in the group of *M. trilobata*) and the flagellum forms a thin ridge along the posterior edge of the anterior. Finally, in the small group of *M. bifida,* which differs from the others mainly in characters pertaining to the brood pouch of the female, the anterior lobe is divided vertically by a narrow pit or furrow.

The female form has been determined for 15 of the 20 odd species here distinguished and assigned to the genus. Most of the exceptions are accounted for by the five species comprising the group of *M. trilobata.* In 13 of the 15 species of which the female form is known the distinguishing brood pouch is essentially of the same type. In these the pouch is large, a quarter-sphere in form, wholly posterior in position, more or less sharply defined on its inner side, extends from about the middle of the ventral border to a point near the post-dorsal angle, and covers the posterior lobe completely on its straight or slightly concave inner side and the posterior half of the elevated border on its outer side. In *M. bifida* and *M. ultima* the pouch holds the same position but is smaller, its outer limit being at the inner base of the elevated border which therefore is continued around it.

Genotype.—Mastigobolbina typus new species.

So far as known the species of this genus are confined to deposits of Clinton age in the Appalachian region. In this they range from the vicinity of Clinton in central New York through Pennsylvania, Maryland, and the Virginias into northeastern Tennessee. The type seems to be entirely unrepresented in the large ostracodal faunas of similar age on the Island of Anticosti. And in the opposite direction, in Alabama, where the Clinton is well represented in the Red Mountain formation and in places is highly fossiliferous, no ostracoda of any kind have been found. However, nearby, in northwestern Georgia—where Middle Clinton sandstone, containing an ostracod fauna comparable to that found in beds of corresponding age in Virginia, Maryland and New York, occurs at the north end of Lavender Mountain near Rome—a few specimens of *M. lata* have been found together with an abundance of *Zygobolbina conradi*. Except this occurrence in Georgia the geographic range of *Mastigobolbina* thus appears to be practically the same as that of *Bonnemaia*.

The stratigraphic range of *Mastigobolbina*, however, is wider than that of *Bonnemaia*. But even in this respect there is agreement between them in so far as the 15 species and varieties of the groups of *M. typus*, *M. trilobata*, and *M. bifida* are concerned. Namely, all but one of the 15 are found in the two Upper Clinton *B. rudis* and *M. typus* zones beneath the Keefer sandstone. The exception in both cases is a Middle Clinton species. As regards the remaining species, the 6 comprised in the group of *M. lata* all occur only in Middle Clinton zones, whereas the three of the group of *M. incipiens* are found in a lower bed that is referred provisionally to the top of the Lower Clinton or the base of the Middle Clinton.

TABLE SHOWING STRATIGRAPHIC DISTRIBUTION AND CLASSIFICATION OF THE SPECIES OF MASTIGOBOLBINA

	Lower Clinton	Middle Clinton			Upper Clinton	
	?. Z. decora zone	Z. emaciata zone	M. lata zone	Z. postica zone	B. rudis zone	M. typus zone
I. Group of *Mastigobolbina typus*. Posterior lobe small, flagellum well developed and so curved that it extends first forward and then backward across the anterior lobe; brood pouch covering posterior half of border.						
M. typus n. sp.	....	....	....	....	....	x
M. typus angulata n. var.	....	....	....	....	....	x
M. typus prænuntia n. var.	....	....	....	....	x	....
M. triplicata (Fœrste)	....	....	....	....	....	x
M. arguta n. sp.	....	....	....	....	....	x
M. intermedia n. sp.	....	....	....	....	....	x
M. rotunda n. sp.	....	....	....	....	....	x
M. modesta n. sp.	....	....	x	....	....	....
II. Group of *Mastigobolbina trilobata*. Posterior lobe nearly as large as the anterior, both extending to the submarginal furrow; flagellum imperfectly developed or wanting.						
M. trilobata n. sp.	....	....	....	....	....	x
M. arctilimbata n. sp.	....	....	....	....	....	x
M. glabra n. sp.	....	....	...	....	....	x
M. punctata n. sp.	....	....	....	....	....	x
M. micula n. sp.	....	....	....	....	x	....
III. Group of *Mastigobolbina bifida*. Posterior lobe narrow, anterior lobe divided vertically by a furrow, brood pouch confined to space within the elevated border.						
M. bifida n. sp.	....	....	....	....	x	....
M. ultima n. sp.	....	....	....	....	x	....
IV. Group of *Mastigobolbina lata*. Posterior lobe narrow, flagellum represented by a but slightly curved crest extending to the dorsal edge or more or less obsolete.						
M. lata (Hall)	....	....	x	....	....	....
M. lata nana n. var.	....	....	x	....	....	....
M. vanuxemi n. sp.	...	....	x	....	....	....
M. clarkei n. sp.	....	....	x	....	....	....
M. declivis n. sp.	....	....	x	....	....	....
M. virginia n. sp.	....	....	....	....	x	....
V. Group of *Mastigobolbina incipiens*. Posterior and anterior lobes large, posterior sulcus narrow and shallow, flagellum running along inner edge of anterior lobe to the dorsal edge where it turns sharply forward and ends on the anterior slope.						
M. incipiens n. sp.	....	x	....	....	....	....
M. producta n. sp.	....	x	....	....	....	....
M. retifera n. sp.	....	x	....	....	....	....

The most interesting peculiarity, which has suggested the name *Mastigobolbina* and marks particularly the typical section of the genus, is the lash-like anterior extension of the ventral extremity of the median lobe, usually referred to in these pages as the flagellum. This forms a thin, usually sharply defined, low to high, recurved ridge traversing the outer surface of the thick lower and median parts of the anterior lobe. It is somewhat less clearly indicated also on the inner surface of the valves, though here it appears as a groove; and in corresponding manner as a low recurved ridge on clean casts of the interior. The flagellum may be analogous to the ribs traversing the surface of the valves in *Steusloffia*,[1] a genus of Ostracoda established some years ago by the writers for certain Baltic species previously assigned to *Beyrichia* and now regarded as probable members of the Zygobolbidæ. However, the arrangement of the ribs in *Steusloffia* is so different from that of the flagellum in the majority of the species of *Mastigobolbina* that one is disposed to doubt that the two are structurally analogous. Apparently there may be or perhaps is good ground for that belief only in the case of the group of *M. incipiens*. But the three species of that group are the oldest of the genus and seem either not yet to have acquired the characters that mark the more typical sections of the genus or they represent an early independent line that may have led to *Steusloffia* or to some other at present unrecognized or unknown ancestor.

Without speculating as to what future investigations may establish it is clear enough at present that *M. incipiens* and its immediate allies are not wholly unquestionable members of the genus *Mastigobolbina*. It is clear also that their particular combination of characters is synthetic in suggesting relations not only to *Steusloffia* and *Mastigobolbina* but also to such other members of its family as *Klœdenia, Zygobeyrichia, Welleria*, and *Plethobolbina*. However, these relations are suggested in most cases by merely generalized similarity in the males that may be interpreted equally well in two or more ways. But this is not so of the females, the brood pouch in the group of *M. incipiens* being precisely the same in form

[1] Ulrich, E. O., and Bassler, R. S., Preliminary Revision of the Beyrichiidæ: Proc. U. S. Nat. Mus., vol. xxxv, 1908.

and position as in otherwise more typical species of *Mastigobolbina* and not as in the other genera mentioned in this connection.

On casual comparison one would hardly suspect that *Plethobolbina typicalis* really can be linked very closely to typical *Mastigobolbina* by a chain of intermediate species. Nevertheless, it is true at least in so far as the valves of male specimens can show relationships. Indeed, the transition from the one to the other becomes so obvious and convincing that we cannot doubt that such widely differing species as *Mastigobolbina typus* on the one extreme of the chain and *Plethobolbina typicalis* on the other are in fact closely allied genetically. To realize the closeness of the links of this chain one needs but to compare *M. typus* with *M. triplicata* and then in order the stages to which we have applied the names *M. arguta, M. intermedia, M. trilobata, M. glabra, M. punctata, Plethobolbina ornata, P. cornigera* and finally *P. typicalis.* If there is any real break in this chain we have failed to detect it. The only element of uncertainty in the matter is that the latter half of the chain, with the possible exception of *P. typicalis,* is based solely on specimens believed to be males.

It should be observed that a brood pouch has not been positively recognized in *Plethobolbina.* In four of the five species of *Plethobolbina* this failure may be accounted for on the ground of insufficient material, only a few specimens of each being known. But this explanation seems inadequate in the case of the relatively abundant *P. typicalis.* However, study of many specimens of the latter suggests that the two sexes are distinguishable but much less different in appearance than is the case in species of *Mastigobolbina.* Critical comparisons seem to establish that some specimens of *P. typicalis* (see Plate LIII, Figs. 32 and 33) are slightly fuller in the post-ventral part than the others. Probably these slightly more ventricose examples are female individuals of the species.

Definitely recognizable females of at least five of the following species of *Mastigobolbina* also have not been observed. However, this conclusion may be at least partly in error because the great brood pouch covers that part of the valves on which the more conspicuous of the specific peculiarities are found and in consequence of which the females of the several species of *Mastigobolbina* are much more difficult to distinguish than are the males. It is possible therefore that the female of *M. glabra,* for instance, may have been referred to the closely related *M. trilobata* which is found in the same beds. However, such possible errors in identification seem less likely in the cases of *M. arctilimbata* and *M. punctata,* because these two species are marked by peculiarities that should be recognized almost as readily in the female as in the male.

As the specimens referred to *M. arctilimbata* and *M. punctata* have larger and fuller posterior lobes than do *M. typus, M. triplicata, M. modesta* and other species of their type, two thoughts are suggested: (1) that *M. arctilimbata* and *M. punctata* are based on female individuals and not males, and (2) that the sexes in these species are either not distinguishable externally or that they are united in the same individual. But none of these possibilities seem at all probable, strong doubt being warranted by the fact that, although the male carapace of *M. trilobata* possesses a posterior lobe nearly as large as those found in *M. arctilimbata* and *M. punctata,* the brood pouch in the female of *M. trilobata* is about as large and otherwise practically the same as in *M. typus.* That the type specimens of *M. arctilimbata* and *M. punctata* are actually males and not females is further indicated if not completely established by the fact that in these specimens the concave border is developed on the posterior side about as well or better than on the anterior, whereas in all the species of the genus of which both males and females are known the brood pouch of the latter entirely covers the area occupied in the male by the widest part of the submarginal furrow.

The relations of *Mastigobolbina* to *Bonnemaia* are discussed at length in remarks following the description of that genus. As to *Klœdenia, Zygobeyrichia,* and *Welleria* it hardly seems necessary to spend much time in showing wherein they differ. The male carapaces in those genera are always sufficiently characteristic to leave no doubt regarding their distinctness from those of *Mastigobolbina;* and when it comes to their female forms there is even less excuse for confusion with the present genus. In *Mastigobolbina* the brood pouch is large and wholly posterior in position, in *Klœdenia, Zygobeyrichia,* and *Welleria* it lies mainly on the ventral side.

As will be noted on comparing the illustrations of species of the two genera herein published, *Mastigobolbina* presents a general resemblance to *Beyrichia*. In fact, the previously described species of the former have hitherto been referred to *Beyrichia*. But with the material and information now in hand the new genus is easily distinguished from the older.

The peculiarities mainly relied on in separating *Mastigobolbina* from *Beyrichia* concern the position, form, and size of the brood pouch. In *Beyrichia* this pouch lies on, or rather covers, the post-ventral quarter of the valves and consequently permits the dorsal half of the posterior lobe to remain visible as in the male. Its form and prominence may be described as egg-shaped or subglobular (see Plate LXIII, Figs. 24 and 30). In *Mastigobolbina* the brood pouch is relatively much larger, obliquely quarter-globular in form without constriction of its base, hence, not so sharply outlined; and it covers all of the posterior third or more of the valve, so that nothing of the posterior lobe remains visible in the valves of the female.

Among other differences of probably inferior physiological importance the most striking peculiarity of *Mastigobolbina* is the whip-lash-like prolongation of the ventral extremity of the median lobe that we usually refer to under the term flagellum. This peculiar feature is suggested in the groups of *Beyrichia clavata* and *Beyrichia interrupta*.[1] Nothing of the kind is seen in the more typical sections of *Beyrichia*. Of the less typical groups mentioned that of *B. clavata* is provided with a brood pouch like that prevailing in typical *Beyrichia*, hence, generic alliance with *Mastigobolbina* is out of the question. As to the "group of *B. interrupta*," its relations to *Mastigobolbina* are not so easily determined because, so far as known to the writers, their female forms have not been described except in one instance, *B. damesi* Krause. In this Silurian species the brood pouch resembles those of *Klœdenia* and *Zygobolba* rather more than those of either typical *Beyrichia* on the one extreme and *Mastigobolbina* on the other. In the other species of this doubtful group of *Beyrichia* the female

[1] Ulrich, E. O., and Bassler, R. S., Preliminary Revision of the Beyrichiidæ: Proc. U. S. Nat. Mus., vol. xxxv, 1908, pp. 295-300.

carapace may not be distinguishable from the male, a possibility rendered rather probable by the fact that they are credited to the Ordovician in which age pouch-bearing Ostracoda are very uncommon. If a brood pouch was not developed in them then they should be regarded as generically distinct not only from *Mastigobolbina* but also from *Beyrichia.* Pending the discovery of further evidence on this matter *Mastigobolbina* may be distinguished from the group of *Beyrichia interrupta* by the greater development of the median lobe in *Mastigobolbina,* especially in the direction of the dorsal edge. In *Beyrichia interrupta* and its immediate allies the median lobe is small and located near the middle of the valves or at least a considerable distance beneath their dorsal edges.

The genetic derivation of *Mastigobolbina* is in doubt. Of Ordovician types only *Drepanella* seems an at all likely ancestor, not only of the present genus but of the whole family. As possible links in this line of descent *Drepanella richardsoni* (Miller) and *Ctenobolbina ? tumida* Ulrich, both Richmond fossils, should be mentioned. On another occasion the latter species was referred by the writers to *Beyrichia.* Subsequent study leads to the conclusion that it is not a true *Beyrichia.* It has been thought of in connection with *Drepanella* and also as an incipient member of either *Mastigobolbina* or *Bonnemaia,* but it fits poorly wherever we try to locate it, so that any change in its classification at this time would be of doubtful advantage.

I. Group of *Mastigobolbina typus*

MASTIGOBOLBINA TYPUS n. sp.

Plate XLIX, Figs. 1-6; Plate L, Fig. 5

Description.—Carapace large, the male shell usually 3.5 to 4.5 mm. in length, the female 4.5 to 5.0 mm., the height about two-thirds of the length, the greatest thickness perhaps one-fourth less than the height.

Typical form.—Valves of the male subovate in outline, the greatest length slightly beneath the midheight, the ends rounded, the anterior side more strongly curved in the ventral half than in the dorsal half, the curvature of the latter part being slight. Dorsal edge straight, considerably shorter than the greatest length of the ventral half of the valve, the junction with the curved outlines of the ends sharply angular, often forming a blunt spine at each extremity. Ventral part of outline gently convex, sometimes almost straight in the middle third. Border wide, especially on the posterior and ventral sides, strongly elevated at the outer edge, sloping rapidly inward to the base of the lobe-bearing part of the surface. The post-dorsal part of this elevated border does not terminate at the extremity of the hinge but continues forward within the angle till finally it joins the dorsal extremity of the median lobe. Posterior lobe small, low and narrow, usually crowned with a row of small nodes, the wide space behind it appearing depressed and usually smooth. Median lobe thickly fusiform in shape, its most prominent part rounded, smooth or obscurely nodulose, occasionally with a thin rib running down from the nodose area over the tapering ventral part which turns forward and joins the ventral part of the anterior lobe. In the typical form of the species this thin secondary ridge increases slowly in strength downward and yet more as it turns forward to the summit of the anterior lobe. Here it turns rather sharply backward and finally terminates at the inner edge of the anterior lobe and very near the exact middle of the valve. Considered in connection with the median lobe it may be said to resemble the lash of a thick-handled whip. The anterior lobe is large, subtriangular in outline, prominent, obtusely pointed, more or less irregularly tuberculated in its dorsal half, and more sparsely nodose or almost smooth on the steep anterior and ventral slopes. Of the two sulci the anterior one is much the wider and deeper. It lies near the middle of the valves and divides them vertically into approximately equal parts. At the dorsal edge it flares widely, whereas the lower end in certain lights appears as though it bent anteriorly into the narrow loop of the lash. The posterior sulcus is narrow and shallow, though distinct enough, thus corresponding to the weak development of the posterior lobe.

Valves of the female larger and otherwise conspicuously different from those of the male. However, the differences are confined to the posterior third or half, the anterior parts, including the median and anterior lobes, being essentially the same in both. The ventral turn of the flagellum as in Plate XLIX, Fig. 9, sometimes is more broadly curved than in the male. The posterior sulcus appears deeper, wider, and longer than in the males, being clearly defined from the post-dorsal rim to the ventral edge. Behind it the remainder of the valve is entirely occupied by the great brood pouch which is smoothly inflated almost to the form of a quarter-section of a globe. Its inner boundary is sharp, slightly concave, and oblique with respect to the hinge line, its ventral extremity lying directly beneath the middle of the median lobe.

In edge views the broad border appears as a thick concave rim, the inner edge of which is finely denticulated. Within the denticles the inner surface of the rim (see Fig. 8) is fluted parallel to the edge, the purpose of the grooves and ridges evidently being to insure secure locking of the valves when closed. So far as known the two valves overlapped very little (or not at all) at their ventral contact.

The distinctive characters of this fine species are so clearly marked that detailed comparisons, except perhaps with the next following species, *M. triplicata* (Foerste), are scarcely necessary. However this may be, the desire to avoid too much repetition is thought a sufficient excuse to defer all necessary comparisons to the descriptive comments on those of the following species that seem near enough to render confusion at all likely. Conforming to the plan followed throughout these descriptions the species of each genus are compared in their turn only with preceding congeners. But when the relations to a species described on a succeeding page are particularly close anticipatory statements directing attention to the fact will be introduced.

The subordinate name *Mastigobolbina typus* var. *angulata* is proposed for a form that differs from the typical variety of the species in the lesser convexity of its valves and in the elbow-like angulation of the ventral extremity of the flagellum. In both these respects var. *angulata* suggests *M. triplicata* and *M. arguta*. However, the posterior lobe is small as in *M. typus,* therefore not as well developed as in those species. The anterior recurved extremity of the flagellum also is as in *M. typus,* making a narrower loop than it does in *M. triplicata* and *M. arguta.*

Occurrence.—The typical form of the species is rather common and widely distributed in the lower part of the limy upper division of the Clinton. At the railroad cut 1½ miles east of Great Cacapon, West Virginia, it is found in crystalline limestone 23 feet beneath the Keefer sandstone; in the "section near Six Mile House" it occurs abundantly as excellent casts of the interior and exterior in leached argillaceous and finely siliceous limestone 29 feet beneath the Keefer. The species has not been observed in collections made at Cumberland, but as its common associates in other places also have not been found at Cumberland the deduction that the bed itself is absent there may perhaps be warranted. In Virginia it has been noted at Williamsville and at Gate City. In Pennsylvania *M. typus* is not uncommon in the lower part of the Upper Clinton at and in the vicinity of Hollidaysburg. It has been found also at Clinton, New York, where it occurs in the *Paleocyclus rotuloides* zone in the upper Clinton a few feet above the oolitic ore bed. Finally, a few specimens that in their usual state of preservation are not easily distinguishable from *M. typus* and especially *M. typus angulata* were detected among thousands of *Bonnemaia rudis* on leached calcareous sandstone occurring near the top of the Clinton as developed on Powell Mountain, about 5 miles northwest of Sneedville, Tenn. These older specimens probably represent a small variety that may be distinguished provisionally as *M. typus prænuntia*. The variety *angulata* occurs in association with the typical variety in the section near Six Mile House, Md.

Collection.—U. S. National Museum.

MASTIGOBOLBINA TRIPLICATA (Foerste)

Plate L, Figs. 1-4

Beyrichia lata—triplicata (part) Foerste, Bull. Geol. Survey Kentucky, vii, p. 329, 1906; Jour. Cincinnati Soc. Nat. Hist., xxi, p. 31, pl. i, fig. 4, 1909.

Description.—As noted above Foerste distinguished this species as a variety from *Beyrichia lata* Hall or *Mastigobolbina lata* (Hall) as it should now be called. Unfortunately, Foerste's types of his variety include specimens of two distinct species, both of which are represented in the U. S. National Museum by good gutta-percha squeezes prepared by the writers about 15 years ago from the originals in the Foerste collection. On comparison both of these forms proved to be represented by indistinguishable though much better preserved specimens in the collections from Maryland and Pennsylvania. In order to recognize Foerste's name *triplicata* it became necessary to redefine and restrict its application to one of the two. Accordingly, the form looking most like the rather poor and evidently generalized figure published by Foerste was selected as typical of the form that should hereafter bear the name. At the same time the "variety" is promoted to the rank of a species. Being a fairly typical species of the genus under consideration it may hereafter be known as *Mastigobolbina triplicata* (Foerste). The other species included in the "variety" by Foerste is next described under the name *Mastigobolbina arguta* new species.

The length in mature examples of the male form of this species varies but little from 2.0 mm. The height of same is about 1.62 mm. In female individuals the length is greater, the average being a trifle under 3.0 mm.

Isolated individuals of this species might easily be mistaken for young examples of *M. typus*, with which indeed it is stratigraphically associated. But after finding numerous specimens, all agreeing in size and structure, it became evident that they belonged to a distinct species. Comparison of the three male valves figured on Plate L can leave no doubt concerning the constancy of the structural peculiarities by which it may be distinguished from *M. typus*. Comparing males of the two species the posterior lobe in *M. triplicata* is found to be relatively larger, with two rows of small nodes instead of one. Besides, the depressed area behind this lobe has more of a slope and carries small pustules that are wanting in *M. typus* and its varieties. Proceeding, the junction of the "lash" and the base of the median lobe is much less curved, appearing, in fact, angular as in *M. typus* var. *angulata*. The posterior outline of the constricted ventral half of the median lobe thus is not convexly curved as in *M. typus* but straight. It also is longer, extending quite to the marginal furrow.

For the same reasons the ventral part of the lash is straight instead of curved. Following the lash anteriorly it is noted further that the recurvature of its end makes a much wider curve, and this distinguishes it particularly from the var. *angulata* of that species. The dorsal extremity of the anterior lobe exhibits commonly still another difference in that it usually terminates in a relatively smooth cone instead of a tuberculose protuberance. Finally, the valves as a whole seem to be deeper, so that the exterior view presents a less emaciated appearance than pertains to the larger species. This is especially so when compared with the variety *angulata*. All of these differcnces are observable also in comparing the females of the two species except those relating to the posterior lobe, which, of course, is covered in these by the brood pouch. The latter is practically the same in the two species. The same may be said of the border, the agreement in this feature being particularly noteworthy because these two species differ from all the others in that the post-dorsal part of the border does not terminate at or just in front of the dorsal angle but passes within it to the median lobe.

After the genotype, *M. triplicata* should be compared with *M. intermedia* and *M. arguta.*

Occurrence.—CLINTON. *Mastigobolbina typus* zone. Not uncommonly found in association with *M. typus,* at Hollidaysburg and Lakemont in central Pennsylvania. The original types of the species came from a supposedly corresponding horizon at the top of the Alger formation, in Lewis County, Kentucky.

Collection.—U. S. National Museum.

MASTIGOBOLBINA ARGUTA n. sp.

Plate L, Figs. 6-10

Beyrichia lata—triplicata Foerste, Bull. Geol. Survey Kentucky, vii, p. 329, 1906; Jour. Cincinnati Soc. Nat. Hist., xxi, p. 31, not pl. i, fig. 4, 1909.

Description.—As stated in the introduction to the foregoing description of *Mastigobolbina triplicata* specimens found in Maryland, West Virginia, and central Pennsylvania proved to be conspecific with the second of the two forms on which Foerste based his supposed variety of

M. lata. As the two are clearly distinct and also different from *M. lata* a new name must be applied to the form remaining after the preceding restriction of *M. triplicata.* Accordingly, the name *Mastigobolbina arguta* is proposed.

This species agrees rather closely with *M. typus* and *M. triplicata.* In size it is inferior to the former and superior to the latter, the length of mature males being 2.9 mm. to 3.3 mm., that of the largest female in the collections being 3.85 mm. The relative height varies considerably in different specimens, the height and length in three specimens, comprising the extremes so far observed, being 2.2 mm. by 3.4 mm., 2.0 mm. by 3.0 mm., and 1.46 mm. by 2.50 mm. The first and second of these may be regarded as representing the typical form of the species, the third is a relatively elongated variety.

In addition to the matter of size already mentioned the male form of *M. arguta* differs from *M. typus* and *M. triplicata* chiefly in the relative strength and disposition of features lying behind the median lobe. The most important of these differences concerns the posterior lobe. This is much stronger and more definitely outlined, and its crest is located further away from the median lobe, in *M. arguta.* Moreover, its crest is smooth and the nodes on its outer slope are less conspicuous and sometimes wanting entirely. In definiteness, relative narrowness and height of the posterior lobe and in the width and depth of the posterior sulcus *M. arguta* excels all other species now referred to the genus.

Comparing median lobes the rectangular turn below contrasts obviously with the corresponding part in typical *M. typus;* but a second look may be required to show that it is not exactly the same as in *M. triplicata.* In the latter the ventral extremity of this lobe is high, the descent from it to the marginal furrow being sheer. In *M. arguta,* on the contrary, the surface slopes toward the extremity, reducing its altitude by a half and causing a decided difference in the profiles of the concerned parts. Further, the median lobe as a whole is more erect and relatively less inflated in the present species, agreeing with this feature much better with *M. typus;* likewise in the occasional carination of the crest of the lobe.

The crest does not follow the middle of the lobe but lies near the posterior side.

Regarding the anterior lobe, the facts are again in closer agreement with *M. triplicata* than *M. typus.* This is shown in the general shape and relative prominence of the lobe, in its simple, broadly conical dorsal termination, and in the course of the lash-like extension of the crest of the median lobe. On the other hand the outline of the inner side of the anterior lobe is oblique as in *M. typus* and not vertical as in *M. triplicata.* Finally, the anterior (median) sulcus is appreciably wider and the curvature of the outline of the valves slightly more convex in the ventral part and more broadly arcuate in the antero- and postero-ventral parts.

As the more striking of the above distinctions pertain to the posterior lobe the recognition of the female form of the species, in which this part of the valve is covered by the brood pouch, is not so easily accomplished. Considerable difficulty therefore may be experienced in distinguishing such specimens from those of *M. triplicata* and *M. typus.* Apparently, the only reliable differences are those pertaining to the anterior or median sulcus, which opens more broadly at the dorsal edge in *M. arguta* and the post-dorsal extremity of the elevated border which does not recurve to contact with the median lobe. The female valve is even more difficult to distinguish from that of *M. intermedia.*

Occurrence.—CLINTON. *Mastigobolbina typus* zone. Usually found in association with *M. typus* and *M. triplicata* at localities in the vicinity of Great Cacapon, West Virginia, and Hollidaysburg, Pennsylvania. One and one-half miles east of Great Cacapon its horizon lies 23 feet beneath the Keefer sandstone. Gate City Gap, Virginia, and other localities in Virginia expose its horizon. In Lewis County, Kentucky, it is found in association with *M. triplicata* at the top of the Alger formation.

Collection.—U. S. National Museum.

MASTIGOBOLBINA INTERMEDIA n. sp.

Plate L, Figs. 12-15

Description.—This species is very closely allied to *M. triplicata* with which also it is associated at Lakemont, Pennsylvania. The two agree approximately in size but the present species is constantly shorter so that its outline is correspondingly more rounded, the greater convexity of the ventral side being especially notable. A more important difference is in the posterior lobe. The anteriorly situated crest of this lobe separated from the rather steeply sloping area behind it by only a shallow groove. In fact, when a valve is viewed in unfavorable lighting, the whole area between the posterior sulcus and the bottom of the groove that separates it from the base of the elevated border may appear as constituting a single thick lobe. We have therefore a clearly intermediate condition between that obtaining in *M. typus, M. arguta* and *M. triplicata,* in which only the thin crest of the posterior lobe stands out prominently, and that marking the group of species comprising *M. trilobata, M. glabra* and *M. punctata,* in which the posterior lobe is wide and actually does occupy the whole of the convex area behind the posterior sulcus. Another difference between *M. intermedia* and *M. triplicata* is that in the former the inner crest-like ridge of the posterior lobe passes above without break into the incurving dorsal part of the elevated border, so that the latter appears to fork. In the latter, on the contrary the upper extremity of the posterior lobe barely reaches the base of the border with its summit distinctly beneath the level of the border. Besides, the incurving end of the border does not quite reach the tip of the median lobe. Finally, the curve of the flagellum over the middle part of the anterior lobe is sharper than in *M. triplicata.*

Occurrence.—CLINTON. *Mastigobolbina typus* zone at localities in the vicinity of Hollidaysburg, Pennsylvania.

Collection.—U. S. National Museum.

MASTIGOBOLBINA ROTUNDA n. sp.

Plate L, Fig. 11

Description.—This seems to be a rare species, only one specimen, and that injured on the front border in cleaning, being known. The length of this is approximately 2.13 mm., the height 1.62 mm. Except for the straight but short dorsal edge and projecting cardinal angles the outline is subcircular. The lobation of the valve and the border are essentially as in *M. arguta,* the fusiform lobe being decidedly inflated in the dorsal half and constricted to a narrow, anteriorly curving neck below, the anterior lobe, though narrower and relatively much more prominent, carries a gently curved ridge which represents the more strongly recurved "lash" of the other species, the posterior lobe is thin, low, and ridge-like, the two sulci deep and long, the marginal furrow, especially on the posterior side, wide and deep, and the outermost edge thin and highly elevated. Compared with *M. arguta* the differences in the lobes, sulci, and marginal furrow are such as would naturally result from a shortening of the carapace.

Mechanically shortened valves of *M. lata* and its variety *nana* as for instance those illustrated in Plate LI, Figs. 12 and 13, sometimes appear much like *M. rotunda.* Critically compared, however, differences in the lobes and margin will be observed that satisfactorily demonstrate their specific distinctness.

Occurrence.—CLINTON. *Mastigobolbina typus* zone, 23 feet beneath the Keefer sandstone, at the railroad cut 1½ miles east of Great Cacapon, West Virginia. The same bed contains *M. typus, M. arguta, M. trilobata,* and other ostracods.

Collection.—U. S. National Museum.

MASTIGOBOLBINA MODESTA n. sp.

Plate LII, Figs. 11-16

Description.—Length 2.4 mm., height 1.5 mm. These dimensions were taken from an adult right valve. In hundreds of examples none varies from it in length by more than 0.2 mm. Most of them are only 0.1 mm. or so shorter. Except that it is much smaller this species resembles rather closely the *M. triplicata* and *M. arguta* of the upper Clinton fauna. The flagellum is similarly curved but extends upward to the tip of the anterior lobe. The posterior lobe is narrow and the rather widely crescentic space behind it is flat, giving much the same appearance to this part as in *M. arguta.* However, this upper end of this lobe is thinner than in that species; and the depressed space behind the lobe lacks, as does also the lobe itself, the pustules that occur on these parts in *M. triplicata*. But a more important difference than those mentioned is that the upper two-thirds of the median lobe is more strongly inflated and the constricted lower third thinner than in either of those species. Unfortunately, the preservation of the specimens in a moderately coarse grained sandstone renders more detailed comparisons with those and other species impossible *M. modesta* is of interest mainly in establishing the existence of the *M. typus* group of species in the Middle Clinton. The strongly sigmoid curvature of the flagellum distinguishes it readily enough from all other species of the genus found in its zone.

Occurrence.—CLINTON. *Mastigobolbina lata* zone, 1 mile west of Narrows and in the gap 1½ miles northwest of Warm Springs, Virginia.

Collection.—U. S. National Museum.

II. Group of *Mastigobolbina trilobata*

MASTIGOBOLBINA TRILOBATA n. sp.

Plate L, Figs. 16, 17

Description.—As usual with these Ostracoda the specimens of this species so far observed differ only very little in size and proportions. The length in males it about 2.65 mm., the height about 1.75 mm. The female is somewhat larger, the length in one being 3.5 mm., the height 2.5 mm. The outline of the valves is rather regularly ovate, truncated on the dorsal side, the hinge uncommonly short, its extremities obtusely angular. Except the two deep sulci the surface of the valves is rather uniformly convex, the fusiform median lobe even being somewhat flattened in its widest part. The anterior lobe is large, extending laterally with little change in convexity from its sharply defined inner side to the bottom of the furrow which marks off the relatively narrow anterior part of the border. The posterior lobe is broad, taking in all the space between the posterior sulcus and the base of the moderately wide posterior part of the concave border. The anterior sulcus is deep, nearly vertical, flares dorsally, and extends about two-thirds across the convex part of the valve. The posterior sulcus is narrow, more uniform in width, and longer but does not reach the concave border. Of the flagellum only the semicircular terminal part which lies on the most prominent part of the anterior lobe is developed as a distinctly elevated crest. Otherwise the surface of the lobes is quite smooth.

This species is distinguished from *M. typus, M. triplicata, M. arguta* and *M. intermedia* by its short hinge, more regularly ovate outline and much broader posterior lobe. On further comparison each of the mentioned species is found to differ in one or more additional respects. Doubtless the following *M. arctilimbata* and *M. glabra* are to be counted as nearer allies.

Occurrence.—CLINTON. *Mastigobolbina typus* zone, 1½ miles east of Great Cacapon, West Virginia, and at Lakemont, near Altoona, Pennsylvania. Also in the soft shale above the oolitic ore at Clinton, New York.

Collection.—U. S. National Museum.

MASTIGOBOLBINA ARCTILIMBATA n. sp.

Plate L, Figs. 18-20

Description.—This seems to be a close relative of *M. trilobata.* At first the possibility that it might be the female form of that species was considered but more critical comparisons revealed differences that could not be reconciled with that view; and it was entirely abandoned when the real female of *M. trilobata* was discovered. In some respects the present species is even more like the following *M. glabra,* which see for comparisons. In the matter of size and general form there is no essential difference between these three species, the length and height of a mature example of *M. arctilimbata* being, respectively, 2.5 mm. and 1.67 mm.

Compared with male valves of *M. trilobata* the two species are found to differ in the width of the border, in the size of the posterior lobe, and in the direction of the sulci. Thus, the border is flatter and narrower all around the free edges and narrowest on the posterior side, which is the direct opposite of the condition obtaining in all of the species described on preceding pages. Next the posterior lobe is even wider than in *M. trilobata,* being broadly crescentic in outline—in fact nearly semicircular or, more properly, approximately a quarter globe in form. Finally, the posterior sulcus is less curved and more nearly ventrical in direction, the anterior sulcus, on the contrary, being more oblique and its anterior side less curved. To these differences is to be added the fact that the flagellum is entirely lost, not a vestige of it being discernible on either the ventral slope or on the median part of the great anterior lobe.

The female form of the species has not been observed. Probably this is to be ascribed to the rarity of the species, only two specimens having so far been seen.

Occurrence.—CLINTON. *Mastigobolbina typus* zone, 23 feet beneath the Keefer sandstone, at the railroad cut 1½ miles east of Great Cacapon, West Virginia. Here it was found associated with *M. typus, M. triplicata* and other Ostracoda marking this zone. Another specimen, smaller and supposedly immature, was found in corresponding beds at Lakemont, Pennsylvania.

Collection.—U. S. National Museum.

MASTIGOBOLBINA GLABRA n. sp.

Plate L, Fig. 21

Description.—Length 3.17 mm., greatest height 2.98 mm. Valves subovate with rather short hinge, the anterior side strongly rounded in lower half but oblique and straight in upper half, the antero-cardinal angle sharp, about 120°, the post-cardinal angle more obtuse. Border wide, especially on posterior side, deeply concave. Surface within border strongly and rather uniformly convex, the sulci appearing as trenches cut into it. Lash indistinguishable on the medio-ventral slope, barely indicated on the anterior lobe, broadly curved.

The general aspect of this species is exceedingly like that of *M. trilobata,* the agreement being particularly notable in the form of the lobes and sulci, in the size and local development of the border, and in the outline of the valves. Perhaps it should be viewed as a variety of that species. However that may be, the two forms are distinguishable. In the first place the flagellum is practically obsolete externally, hence much less developed than even in *M. trilobata* and the trace that remains of it apparently merely a thinner part of the test in which the color is different from the remainder lies nearer the posterior edge of the anterior lobe and makes a wider curve. The anterior (wider) sulcus has straighter sides and is a little more oblique with respect to the hinge line and the posterior one also is straighter and slightly stronger. Finally, the posterior lobe is proportionately a trifle wider, the inequality in height of the anterior and posterior halves of the valves is a little greater and the dorsal extremity of the anterior lobe carries a small conical node that is lacking in *M. trilobata.* Though none of these differences would by itself be considered important it does not seem right to dismiss them so lightly when so many minor disagreements are presented in combination.

Most of the differences used in separating *M. trilobata* from *M. arctilimbata,* the main exception being that in the latter also the flagellum is obsolete, will serve also in discriminating *M. glabra.*

Occurrence.—CLINTON. Near base of *Mastigobolbina typus* zone, at Lakemont, Pennsylvania. The species seems to be rare.

Collection.—U. S. National Museum.

MASTIGOBOLBINA PUNCTATA n. sp.

Plate L, Figs. 22, 23

Description.—This also appears to be a close ally of *M. trilobata* and *M. glabra* but possesses peculiarities by which it is easily distinguished. It seems to be a smaller species, the length and height of the type specimen being, respectively, 2.25 mm. and 1.46 mm. On comparison with its nearest relatives the peculiarity that will be at once observed, shown in casts of the interior as well as in testiferous specimens, is the extreme narrowness and shallowness of the posterior sulcus. Though having about the same curvature and direction with respect to the dorsal edge as has the corresponding sulcus in *M. trilobata,* the difference in width and depth is very striking. The anterior sulcus, also, except that it is slightly narrower, agrees very well with the corresponding depression in *M. trilobata.* The reduction in the width of the sulci is appropriated by the posterior lobe, which consequently is wider than is the same part in its allies. The width of the border is less than in either of the mentioned species, the agreement in this feature being with *M. arctilimbata.* However, though the border is narrow all around, its widest part is on the posterior side and not, as is the case in *M. arctilimbata,* on the anterior side. Finally, magnification of the surface of the shell shows that it is closely but distinctly punctate—almost reticulate—a feature observed in only one other species of the genus, namely *M. retifera.* The flagellum is developed about as in *M. trilobata,* though more distinctly defined in its ventral part. However, it is barely elevated being notable because it lacks the punctations of the remainder of the surface.

The narrow, slit-like posterior sulcus recalls *M. clarkei* in which this sulcus is similarly reduced. That species, however, is at once distinguished by the smallness of its posterior lobe and the wide depressed space that lies between this lobe and the outer border.

As pointed out in the generic discussion, *M. punctata* is regarded as an important species in establishing the transition from the bilobed species of *Plethobolbina* to the trilobed forms.

The next in line in the suggested transition to that genus is *P. ornata* in which the posterior side of the post-median lobe is very obscurely outlined.

Occurrence.—CLINTON, Lakemont, Pa. Here it is associated with *M. typus, M. triplicata, M. glabra,* and other Ostracoda. Also in the soft shale above the oolitic ore at Clinton, New York.

Collection.—U. S. National Museum.

MASTIGOBOLBINA MICULA n. sp.

Plate LI, Fig. 24

Description.—As near as can be determined an average example of this species is 1.37 mm. in length and 0.94 mm. in height. The specimens occur in a sandy shale and have been flattened with the compacting of the beds so that their original thickness cannot be accurately ascertained. The species seems rare, only a few valves of males and none of females having been found.

The systematic relations of *M. micula* are somewhat doubtful. It suggests *Klœdenia* but not enough to overcome our conviction that it belongs nearer such Mastigobolbinas as *M. clarkei* and *M. arctilimbata.* It is smaller than either of those species but agrees rather well with them in general aspect and particularly with the former in the relative shortness of its sulci. On the other hand it differs from *M. clarkei* in the narrower median sulcus, wider as well as less slit-like posterior sulcus, and broader posterior lobe. Except that the median sulcus is narrower and the posterior lobe not quite so wide the general appearance of the convex part of the valves is much the same as in *M. arctilimbata.* However, the exceptions mentioned together with the fact that the border in *M. micula* is relatively wider establishes beyond question that these are not merely young specimens of *M. arctilimbata.*

Occurrence.—CLINTON. One hundred and two feet beneath top of Keefer Sandstone, near Six Mile House, Maryland.

Collection.—Maryland Geological Survey.

III. Group of *Mastigobolbina bifida*

MASTIGOBOLBINA BIFIDA n. sp.

Plate LII, Figs. 17-20

Description.—This is a small transversely ovate species, with the males and females approximately equal in size but differing otherwise in the usual manner. The length and height of an average example is 2.1 mm. and 1.3 mm., respectively. Strangely, about nine-tenths of all specimens so far observed are females.

Except for its smaller size the male form of the species looks in general much like *M. triplicata.* More careful investigation, however, soon brings out a number of minor and two major differences that leave no doubt concerning their actual distinctness. Thus, while the outline, the course and general character of the border, the form of the median lobe and the form of the depressed areas of the surface are similar enough to require a second look it may be noted at once that the anterior lobe instead of being triangular in form and highest in its median part is divided by a deep vertical furrow into two approximately equal narrow ridges, the outer one somewhat lower than the inner. Next it will be seen that the ventral confluence of the lobes is thicker, the median sulcus being correspondingly shorter. Further it will be noted that the posterior sulcus does not cut through the ventral ridge and that the posterior lobe is narrower and more definitely bounded on its posterior side.

The female form differs from the male in that its posterior third is occupied by a swelling—the brood pouch. Though holding the usual position, the pouch in this species is relatively smaller and less sharply defined from the rest of the valve than is the corresponding feature in *M. typus, M. triplicata* and other species of the typical section of the genus. In fact, its nature may not be immediately apparent, this perhaps mainly because of the uncommon fact that it does not cover the posterior part of the border but extends only to its inner base, thus appearing more like a thick posterior lobe as in *M. arctilimbata* and its allies than the type of brood pouches found on the females of most other species of the genus.

Only one other species has a similarly confined and delimited brood pouch, namely *M. ultima.* Though clearly allied to *M. bifida* and also found in the same zone though not certainly identified in Tennessee, it is easily distinguished by its smaller size and by certain structural characters that are pointed out in following notes.

Occurrence.—CLINTON. *Bonnemaia rudis* zone. Powell Mountain, about 5 miles northwest of Sneedville, Tennessee. At this place the zone lies at the top of the Clinton, the two succeeding zones of the upper Clinton being absent either because of non deposition or removal by erosion prior to the overlap of the formation by the Sneedville limestone which commonly succeeds the Clinton in southwestern Virginia.

Collection.—U. S. National Museum.

MASTIGOBOLBINA ULTIMA n. sp.

Plate LI, Figs. 21-23

Description.—A small left valve, male, is 1.44 mm. in length and 0.95 mm. high. In the largest specimen seen, an imperfect left valve, male, the corresponding dimensions are about 1.92 mm., and 1.25 mm., respectively. A left female valve is 1.85 mm. by 1.24 mm. The species does not seem to be very rare but we were sure of it only at one place and even here we found it difficult to procure specimens suitable for photographing.

That *M. ultima* is a close ally of *M. bifida* may be readily appreciated by comparison of the figures of the two. The most important of the points of agreement is in the brood pouch of the female which does not, as in all other species of the genus, cover the posterior part of the elevated rim. Another is the fact that the anterior lobe is divided vertically by a furrow, only this furrow lies more on the anterior slope so that the outer division of the lobe lies at a lower level and appears much thinner in a side view of the valve than in *M. bifida.* Of less important differences we would call attention to the less angular dorsal extremities and more equally rounded ends. The form of the posterior lobe and its relations to the depressed spaces on either side of it also are not precisely the same in the two species. Finally, the average size of the present species is considerably inferior to that of *M. bifida.* In our experience specimens differing notably in size usually prove on closer investigation to differ also in other respects.

So long as the female of this species had not been recognized the males were mistakenly supposed to represent a derivative of *M. lata* or of its variety *nana.* The brood pouch of the female, however, proved to be quite different from that of *M. lata* and this led to more critical comparison of the male forms of the two. It was then that the furrow in the anterior lobe was observed. Also that the constricted part of the median lobe is narrower, the median sulcus wider in its lower half, and the inner boundary of the anterior lobe more curved and less oblique to the dorsal edge in *M. ultima* than in *M. lata.* The latter differences are not so apparent when the present species is compared with *M. lata nana* but the outline in that earlier form is distinctly shorter.

Occurrence.—CLINTON. One hundred and two feet beneath the top of the Keefer sandstone, near Six Mile House, Maryland. Here it is associated with *Zygosella vallata nodifera* and other characteristic ostracoda of the *Bonnemaia rudis* zone.

Collection.—Maryland Geological Survey.

IV. Group of *Mastigobolbina lata*

MASTIGOBOLBINA LATA (Hall)

Plate LI, Figs. 1-11 and 16 and 19 (part); Plate LII, Figs. 5, 6

Agnostus latus (part) Vanuxem, 1842, Geol. New York, 3d Geol. Dist., p. 80 (name only).

Beyrichia lata (part) Hall, 1852, Pal. New York, ii, p. 301, pl. 466, figs. 10c-e.

Beyrichia lata Jones, 1855, Ann. Mag. Nat. Hist., 2d ser., vol. xvi, p. 168, pl. vi, fig. 13.

Beyrichia lata Foerste, 1906, Bull. Geol. Sur. Kentucky, vii, p. 329.

(Not *Beyrichia lata* Ulrich and Bassler, Proc. U. S. Nat. Mus., vol. xxxv, pl. 292, fig. 25, 1908 (= *M. clarkei* of this work).

Description.—Presumably the collections made and studied by Vanuxem, who was the first to apply the specific name *lata* to Clinton Ostrathe name. However, as he neither described nor illustrated his species coda, included specimens of the form to which it is proposed to restrict it is impossible to determine exactly which form or forms he had in mind. Under the circumstances the species must be credited to Hall, who in 1852 published the first description and figures of a number of specimens referred by him to the species. But Hall's work also failed to fix the species because—under the misapprehension that the two valves are different, one with two lobes, the other with three—the specimens described and figured by him represent at least two very different species. Jones was the first to disagree with Hall's conception of the species and when, in 1855, he described the three-lobed form as *Beyrichia lata* he practically redefined and restricted the species to it.

Long afterwards, Foerste, apparently unaware of Jones' work, similarly restricted the term *Beyrichia lata* to the trilobate form of the species as defined and illustrated by Hall. At the same time Foerste proposed the name *Bollia lata* for the bilobed form. Again he seems to have overlooked the fact that Jones had already used the latter combination when in 1890 he intended to distinguish the bilobed species from the trilobed *Beyrichia* *lata* (Hall) Jones. However, Jones' effort failed on this occasion because the *Bollia lata* described and figured by him is based on a variety of the quadrilobate *Klœdenella symmetrica,* an abundant fossil of the Rochester shale, which he wrongly identified with the very different lower Clinton bilobed ostracode of central New York which Hall had included in his conception of *Beyrichia lata.* The present status of *Bollia lata* Foerste, not Jones, is discussed on another page under the heading *Zygobolbina conradi* n. sp.

Two years after the publication of Foerste's recommendation Ulrich and Bassler published the first true illustration of a specimen occurring with many other beyrichian valves on a slab collected by Hall and labeled by him as *Beyrichia lata.* As the figure published by Jones 53 years before is obviously generalized the specimen selected for illustration by Ulrich and Bassler might automatically assume the rank of the type of the species should any further restriction of its limits be attempted.

During the present study of the species such an attempt became desirable when it was found that the three-lobed specimens in hand from the type locality of *B. lata* in central New York are divisible into four varieties or species. In one of these, herein named *Mastigobolbina clarkei,* the posterior lobe, though narrow, is sharply outlined by the flattening of its surface. The posterior sulcus in this form is very narrow and slit-like, the anterior lobe broad and but moderately convex. In the second form—by far the most common and for this reason the one thought to be the best qualified to become the type of restricted *Mastigobolbina lata*—the posterior lobe consists of a thin rounded or obtusely angulated ridge, the large anterior lobe is rather strongly but not uniformly convex, its inner and higher half presenting a flattened area bounded on the outer side by an obtuse angle beyond which the contour of the lobe drops with a gently biconcave but rather steep slope to the hollow of the border. The median lobe in this form is more inflated and the posterior sulcus (because of the rounding instead of flattening of the summit of the posterior lobe) seems wider than in the first variety. The third form (*M. lata* var. *nana*) is commonly smaller and relatively shorter than the associated varieties. Otherwise it is much like the second form, differing chiefly in that the flattened area of the anterior lobe tilts strongly toward the larger (median) sulcus, the outer edge of the sloping area being not only more acutely angular and ridge-like but also relatively higher. The fourth form here described as new under the name *Mastigobolbina vanuxemi* is like the second except that it commonly attains slightly greater size and proportionately greater length and that the anterior lobe is wider and only very obscurely crested.

The specimen selected and photographed by Ulrich and Bassler to illustrate the species *Beyrichia lata,* part., Hall, belongs to the first of these four forms. It was selected because it seemed to be the best of the specimens turned over to the U. S. National Museum from material labeled *Beyrichia lata* in the original Hall collection. However, as Ulrich and Bassler were not then aware that more than one trilobed species is represented in this supposedly typical material it is almost unnecessary to add that in selecting what they regarded as merely an uncommonly well-preserved specimen of the species there was no intention to restrict the species to some definite form. Moreover, investigation of the material used by Hall in illustrating *Beyrichia lata* and which is now preserved in the American Museum of Natural History, New York City, shows that the first of the three forms above described is not represented in it. Under the circumstances we have no choice but to select some specimen from the original types upon which to found the species as it is now proposed to restrict it; and at the same time it becomes necessary to propose a new name for the form erroneously referred to *B. lata* by us in 1908. So that it may be eliminated from further discussion in this connection it should be said at once that the specimen then figured by us as *B. lata* is now regarded as the type of a new species for which the name *Mastigobolbina clarkei* is herein proposed.

The restriction of the species is thus narrowed to choice between the second, third and fourth forms and quickly decided in favor of the second because it is by far the more abundant and widely distributed of the three. As thus restricted *Mastigobolbina lata,* giving the species its new generic setting is sufficiently illustrated on Plates LI and LII to make very detailed description unnecessary. We may therefore content ourselves mainly with comparative discussions showing in what respects it differs from allied forms.

Before doing so it seems desirable to say that on account of varying appearances, due mainly to matters pertaining to conditions of preservation, it is not easy to distinguish the several forms. Too commonly the exterior molds are not clean, more or less of the ferruginous replacement of the shell being retained. Comparison of Figs. 1 to 11 on Plate LI and 1 to 6 on Plate LII illustrate some of these distressing imperfections. Only Fig. 11 comes near to showing the true characters of the exterior of *M. lata.* In all the other figures, and for one reason or another, the flatness of the tops of the two larger lobes and the sharpness of the keel on the anterior lobe are either not shown at all or but indefinitely. For like reasons the border looks unlike in different preparations and thus may suggest misconceptions concerning variations in outline.

Some of the distinguishing features of *Mastigobolbina lata* (Hall) as here restricted, were mentioned in the foregoing discussion. The male shells of the typical form are exceedingly abundant in certain layers of the Middle Clinton in central New York. As a rule these are of smaller size than those of the associated *M. vanuxemi* and *Zygobolbina conradi.* In one of average adult dimensions the length and height are respectively 2.75 mm. and 1.75 mm. The largest seen is 2.9 mm. in length. The point of greatest thickness lies near the middle of the anterior lobe. Here the thickness of each valve equals something between one-third and one-half of its height. In specimens that, like those from Tuscarora Mountain in southern Pennsylvania, are distorted by pressure, these proportions may be variously modified. The female form of the species is considerably larger than the male, the average length of these being about 3.0 mm. The brood pouch is in all respects as in typical species of the genus.

Compared with preceding congeners the principal distinguishing character of *M. lata* is the ridge-like form of the anterior lobe. The summit of this lobe is not rounded but flat and terminates on its outer side in a sharp edge from which the surface slopes very gently toward the edge of the subcentrally located deep anterior sulcus and with a much steeper concave descent toward the anterior border. The part within the crest of the ridge curves backward below to meet the constricted neck of the median lobe, the joined lobes together forming an irregular U-shaped loop. The ventral part of the loop is thick, the turn on the posterior side rectangular. The lower third of the median lobe is narrow, the upper two-thirds distinctly fusiform though only moderately inflated. The posterior sulcus is deep and narrow, its width being about the same as that of the posterior lobe. The furrow outside of the lobes is rather sharply defined and, as usual in the genus, widest in the post-ventral quarter. The elevated border is thick and rather high, when fully preserved its outer edge faintly concave, and its dorsal termini on either side lie just within the cardinal angles. Of these angles the anterior one is the less obtuse, commonly about 105 degrees. Both are, however, sharply defined.

The flattened summit of the anterior lobe reminds considerably of corresponding parts in species of *Bonnemaia*, especially *B. celsa* and *B. fissa*. Though this resemblance probably is truly indicative of genetic alliance—in the way of convergence in a not distant common root—the general aspect of the concerned species is too different to render confusion between them at all likely. On the other hand, the character referred to serves excellently in distinguishing *M. lata* from all of the previously described species. As it is associated with *M. clarkei* and *M. vanuxemi* more detailed comparison with those species seems desirable. In the first place, the anterior lobe in *M. clarkei* is but moderately and apparently almost uniformly convex, the crest being low or barely distinguishable. In *M. lata* the lobe is more prominent and much more sharply and strongly crested, longitudinal profiles of shells of the two species therefore being very different. Further, in *M. lata* the median lobe is more inflated and its neck thinner, the posterior sulcus is wider and not sharp-edged, and the posterior lobe is proportionally narrower with the crest rounded and never distinctly flat-topped. Finally, the upper half of the anterior side of the outline is less nearly rectangular than in *M clarkei*.

The three species next described, *M. vanuxemi, M. declivis,* and *M. modesta,* doubtless are related to *M. lata* the first two perhaps more closely than the last. It is distinguished from the first by its shorter and more ovate form the ventral part of the outline especially being more arcuate. The border also is somewhat thicker and the excavated part between it and the lobed inner area is not so broad as in *M. vanuxemi.* But the most conspicuous difference between the two, provided good exteriors are available, lies in the surface contours of their respective valves. Namely, in *M. lata* the anterior lobe is sharply carinate so that the inner half slopes strongly down to the edge of the median sulcus. In *M. vanuxemi* on the other hand, the whole anterior lobe is more rounded or at least less angulated in longitudinal profile.

Compared with *M. declivis,* a new species from southern Pennsylvania with similarly carinated anterior lobe the male of *M. lata* is distinguished at once by its more elongate elliptical outline and less inflated median lobe. The female pouch is relatively larger and thicker in *M. lata* than in *M. declivis.*

There seems little danger of confusion with *M. rotunda.* The outline in the two is quite different being nearly circular in that species whereas in *M. lata* the height is decidedly inferior to the length. Comparison of figures of the two on Plates L and LI soon reveals other more or less well-marked differences in the shapes of the lobes and furrows and in their borders. These comparisons establish beyond question that *M. rotunda* is more closely allied to *M. intermedia* and *M. arguta* than to *M. lata.*

The relations to *M. modesta* probably are more intimate though not so close as one might believe on casual comparison. The carina on the anterior lobe, which represents the flagellum of *M. typus* and its immediate allies, is not recurved as in *M. modesta,* nor is the neck-like basal part of the median lobe as thin as in that species. Good specimens, even though but casts of the interior, are really more easily distinguishable than comparison of our imperfect illustrations indicates. The same is to be said of *M. ultima* which we regard as belonging to another group of species. *M. lata* has narrower sulci and differs in various details. The females of the two are quite different.

Occurrence.—CLINTON. *Mastigobolbina lata* zone, New Hartford, New York, Cumberland, Maryland and many other localities in Maryland, Pennsylvania and Virginia.

Collection.—Maryland Geological Survey, U. S. National Museum.

MASTIGOBOLBINA LATA var. NANA n. var.

Plate LI, Figs. 12-17

Description.—The types of this variety are decidedly smaller and relatively shorter than the associated specimens of the typical variety of *M. lata.* In the specimens from New Hartford, New York, the length usually is slightly less than 1.9 mm. In Cove Gap, near Mercersburg, Pennsylvania, however, a few larger specimens (see Figs. 13-15) were found with others of more normal dimensions. These larger valves, like all the other fossils found in the same bed at Cove Gap, have been distorted by pressure so that one cannot be quite sure as to their proper classification. Depending solely on those that retain their original form the variety is distinguished not only by its smaller size and shorter valves but also by the fact that the crest of the anterior lobe is even more prominent, indeed so much so that the summit slopes distinctly inward from the crest. The neck of the middle lobe is somewhat thinner and the inflation of its upper part is relatively greater than in typical *M. lata.*

Variety *nana* somewhat resembles *M. ultima,* a younger species that is figured on the same plate. But the anterior lobe is not so prominent in that species and it has a furrow in its anterior slope that is not present in var. *nana.* But it is the females of the two rather than the males that show what we regard as the most important difference. Namely, in the female of the var. *nana* the brood pouch covers the posterior half of the border the same as it does in all but two of the seventeen species of *Mastigobolbina* of which the female form has been recognized. The exceptions are *M. ultima* and *M. bifida* in which the brood pouch is limited outwardly by the inner base of the elevated border.

Occurrence.—CLINTON. *Mastigobolbina lata* zone, New Hartford, New York. It has not been observed in this zone in either Maryland or

Pennsylvania but has been found in the slightly lower *Zygobolbina emaciata* zone at the toll gate on the Mercersburg and McConnellsburg pike 4½ miles northwest of Mercersburg, Pa.

Collection.—U. S. National Museum.

MASTIGOBOLBINA VANUXEMI n. sp.

Plate LII, Figs. 1-4

Description.—As noted in the preceding discussion of *M. lata* this species is found associated with it at New Hartford, New York. The two occur together also in Maryland and Virginia. Though commonly a little larger and relatively longer than *M. lata,* and therefore likely to be noted in looking over the slabs of sandstone on which they occur, *M. vanuxemi* is distinguished mainly by structural differences. The most striking of these is the general rounding of the surface of the anterior lobe, there being no vertical ridge or crest nor a flattened or inwardly descending slope as in that species. Nor is the anterior slope so broadly and distinctly concave. Besides, the general outline is more elongated and the ventral side always straighter. In comparing exteriors of the two species, as may be done by means of gutta-percha squeezes, the border is found to be thinner and wider and more broadly, that is, not so steeply excavated on its inner side as in *M. lata.* These show also that the depressed area behind the posterior lobe is wider, especially in its upper half in *M. lata.*

Occurrence.—CLINTON. *Mastigobolbina lata* zone, New Hartford, New York, Cumberland, Maryland, and Cumberland Gap, Tennessee. At the last place it is found associated with *M. lata,* and *Zygobolbina conradi* about 100 feet above the iron ore bed. It will be noted that the association of species at Cumberland Gap is practically the same as at New Hartford in New York.

Collection.—U. S. National Museum.

MASTIGOBOLBINA VIRGINIA n. sp.

Plate XLV, Figs. 17 and 18, 15, 16 and 19 more or less doubtful

Description.—The original of Fig. 18, a large left valve of the typical form has a length of 2.46 mm. and height of 1.37 mm. The original of

Fig. 19 in which the dorsal and ventral edges are more nearly parallel than in the typical form, is 2.25 mm. in length and 1.13 mm. in height. Figs. 15 and 16 have been drawn from other specimens that differ in one or more respects from the typical variety of the species.

As comparison of the five figures given under this name clearly shows, we have combined provisionally in one species a number of elongated valves that differ more or less from each other in their respective outlines and lobing. Most of them were found together near Warm Springs, Virginia, and associations of similar forms were observed also at Cumberland, Maryland, and other places showing the same zone. Whether these many valves actually belong to a single variable species, which we doubt, or to several closely allied but distinct species cannot be satisfactorily determined without better material. That in hand is preserved in sandstones of too coarse a grain to permit detailed observations of characters usually employed in distinguishing species of this and allied genera. In the present instance nicety in discrimination is less essential than usual from the standpoint of stratigraphy, because all of the specimens of this type have been observed only in one zone.

Viewed as a single species its nearest ally appears to be *M. vanuxemi* which holds a lower position in the Clinton group. Except Fig. 15, which comes nearest to that species, *M. virginia* differs in its outlines. The anterior side is more produced in its lower half and the two ends usually are more nearly equal in height. The ventral side also commonly differs in being straighter and in many specimens it more nearly parallels the dorsal edge. Excepting Fig. 16, which is peculiarly inflated in its post-ventral part and may be an abnormal individual, the median sulcus flares more in dorsal direction than in *M. vanuxemi*. Commonly, too, the border looks different, being narrower especially on the anterior side of the specimens which are regarded as typical. Probably of greater importance than any of the differences so far mentioned is the fact that in all of the specimens provisionally assigned to *M. virginia* the posterior lobe, especially its lower half, is decidedly thicker than in *M. vanuxemi*.

Occurrence.—CLINTON. (*Bonnemaia rudis* or *Mastigobolbina typus* zone) Wills Creek in Cumberland, Maryland, in the gap 1½ miles northwest of Warm Springs, Virginia, and other localities where the same horizon is exposed.

Collection.—U. S. National Museum.

MASTIGOBOLBINA CLARKEI n. sp.

Plate LI, Figs. 18-20

Beyrichia lata Ulrich and Bassler, 1908 (not Hall), Proc. U. S. Nat. Mus., vol. xxxv, p. 292, fig. 25.

Description.—Length of holotype, a right valve from New Hartford, New York, 2.50 mm., height of same 1.71 mm.; the same measurements in a smaller right valve from central Pennsylvania give 2.33 mm. and 1.54 mm., respectively. The latter seems to be relatively very slightly the longer but close investigation shows that most of the difference is due to incomplete preservation of the ventral part of its border.

As stated in the preceding discussion of *M. lata,* in which that species is redefined and restricted, the holotype of *M. clarkei* was discovered by the writers in material out of the original Hall collection that bore the label *"Beyrichia lata."* Being in an unusually good state of preservation and also as we were as yet unaware of the fact that the Clinton trilobate ostracoda then generally referred to as *Beyrichia lata* are divisible into many distinct species and varieties, we figured the specimen referred to as a good representative of Hall's species. Now, since we have learned that Hall's original type does not include specimens precisely like the one figured by us in 1908 it has become necessary to remove it from Hall's species and to propose a new name for it. The type of the species being a New York fossil we have chosen to name it after Dr. J. M. Clarke who has been so long and so worthily connected with geological work in that state.

M. clarkei is distinguished from *M. lata* and its varieties by its more nearly rectangular antero-dorsal outline, the flatness of the posterior lobe, the sharp definition and narrowness of the posterior sulcus, the relative shortness and smallness of the median (or anterior) sulcus, and the relatively even and more moderate convexity of the anterior lobe. Cresting of this lobe is barely indicated. A few other differences may be observed in critical comparisons of the illustrations on Plate LI. The median lobe especially may be mentioned as worthy of investigation. Likewise the furrow and depressed area between the elevated border and the lobed area.

M. vanuxemi, which also is found in the *M. lata* zone, is a longer form and differs more or less decidedly in the details of its lobing. These differences hardly need to be pointed out being readily appreciable by comparison of figures of the two in Plates LI and LII. Of remaining species only *M. micula* looks much like *M. clarkei* in outline and disposition of parts. Starting with this great disparity in size, that being much the smaller, the discrimination in this case should be comparatively easy.

Occurrence.—CLINTON. *Mastigobolbina lata* zone at New Hartford, New York, ¾ mile north of Reedsville, Pennsylvania, and at Cumberland, Maryland, where it occurs about 120 feet above the top of the Tuscarora sandstone.

Collection.—U. S. National Museum.

MASTIGOBOLBINA DECLIVIS n. sp.

Plate LII, Figs. 7-10

Description.—Three valves have the following dimensions: a right valve has a length of 2.70 mm. and height of 1.85 mm.; a left valve is 2.62 mm. long and 1.70 mm. high; and a right valve of a female is 2.50 mm. long and 1.62 mm. high. The point of greatest thickness lies on the crest of the anterior lobe near the middle of this half of the valve. It amounts to nearly half of the height. Some of the specimens show variations in their proportions and in their outlines that evidently are due to distortion by pressure in folding of the beds.

Fig. 7 represents what we regard as the normal form of a right valve of this species. Judging from this the more obvious relations of the species are with *M. lata* and, because of the rounded form and relatively greater height, the var. *nana* particularly is suggested. The same variety is further suggested by the extraordinary prominence and sharpness of the crest of the anterior lobe, the inward slope of its flattened top and the steepness of the anterior slope. But it requires only a glance to satisfy one that *M. declivis* is distinct from both the typical form of *M. lata* and its var. *nana*. Compared with the latter its valves, referring now to males, are constantly larger, the posterior lobe narrower and shorter, the middle lobe thicker, especially in its constricted lower third, and its axis more oblique to the hinge line. Further, the dorsal extremity of the anterior lobe is more pointed, and the curvature of the crest of this lobe as seen in side views, is different, its course in *M. lata* and its varieties being such that it is convex anteriorly throughout its length whereas in *M. declivis* it changes its course sufficiently before reaching the dorsal edge to warrant one in describing it as imperfectly sigmoid. Finally, the most anterior point in the course of the crest lies farther up and the upward turn from its ventral part accordingly in less abrupt and broader than in the varieties with which we are comparing it. The female of the two species differ further in that the brood pouch is both smaller and less prominent in *M. declivis* than in *M. lata.* While the closeness and also the truly genetic character of the relations of *M. declivis* to *M. lata* are scarcely to be denied, it yet may seem probable that the genetic ties between the present species and *M. modesta,* and perhaps through this to the *M. typus* group of species, are even stronger. Of course, there is little or at least less excuse for confusion with *M. modesta* because the decidedly sigmoid curvature and the linear elevation of the flagellum and the smallness of the neck of the middle lobe in that species contrast too obviously with the characters of corresponding parts in *M. declivis.* Nevertheless, this species simulates the *M. typus* group of species in precisely those features that distinguish it from *M. lata* and its immediate allies. It occupies, therefore, an intermediate position between the two groups of species, but whether its apparently transitory combination of characters is to be viewed as a link in a line of evolution connecting the two groups or as a stage in a separate but similarly modifying line cannot be determined with the material in hand. That we lean for the present toward the latter view is indicated by our provisional assignment of the species to the group of *M. lata.*

Occurrence.—Clinton. *Zygobolbina emaciata* zone, Cove Gap, Tuscarora Mountain, 4½ miles northwest of Mercersburg, Pennsylvania. The extension of these beds in Maryland has not been searched for ostracoda by the writers. Doubtless this and other species occur there as in Pennsylvania.

Collection.—U. S. National Museum.

V. Group of *Mastigobolbina incipiens*

MASTIGOBOLBINA INCIPIENS n. sp.

Plate LIII, Figs. 8-12

Description.—Dimensions of a right male valve, that retains most of the wide concave border: length 2.32 mm., height 1.44 mm.; same of a left valve that has lost most of its border: length 2.12 mm., height 1.31 mm.

In the perfect state the free edges of the valves of this species are surrounded by a wide and rather deeply concave thin border or frill that projects beyond and overhangs the contact margin. It is easily broken away and in the highly ferruginous and spongy matrix in which the species is found at Frankstown, Pennsylvania the border is commonly lost in removing the specimen. The greater part of the median lobe is a moderately prominent convex subelliptical elevation contracting downward into a narrow neck. The latter then passes into a thin ridge (flagellum) that curves around the base and then up the anterior side of the moderately deep median sulcus to the dorsal edge where the ridge turns abruptly forward and downward to end near the middle of the outer edge of the anterior slope. This thin ridge shows on interior casts (see Plate LIII, Fig. 12) as well as the exterior surface. The posterior sulcus is merely a shallow depression between the elliptical median lobe and the broad convexity behind it that represents the posterior lobe. The anterior lobe is very broad, covering all the space between the median sulcus and the marginal furrow. Except the flagellum, which surrounds its dorsal half the surface of the anterior lobe is moderately and rather uniformly convex. In the ventral slope just beneath the median lobe and between the obscurely defined ventral extremities of the anterior and posterior lobes is a shallow depression. This is a family mark common to and usually more strongly developed in the Beyrichinæ and the trilobed Zygobolbidæ.

The brood pouch of the female is a large and prominent inflation of the surface agreeing in position, size and form very closely with the corresponding feature in both the *M. typus* and *M. lata* groups of the genus.

None of the species described on preceding pages are sufficiently like this to require detailed comparison. The position and course of the flagellum is characteristic while the fulness of the anterior and posterior lobes is equalled only in the group of *M. trilobata.*

Occurrence.—So far this species has been found only in a thin bed of fossiliferous iron ore lying about 8 feet above the main ore seam near Frankstown, Pennsylvania. The same layer contains also *M. producta, M. retifera, Zygobolba buttsi* and other species of ostraeoda that have not been found elsewhere. The Frankstown ore bed probably represents a fossil zone between those of *Zygobolbina emaciata* and *Zygobolba decora.* However, as neither of the mentioned zones were recognized in the Frankstown section the accurate determination of the position of this ore seam in the sequence of Clinton ostracod zones is a matter for future investigation. Provisionally it is assigned to the "top of the Lower Clinton."

Collection.—U. S. National Museum.

MASTIGOBOLBINA PRODUCTA n. sp.

Plate LIII, Figs. 13-17

Description.—A large mold of the exterior of a left valve, without the outer border, is 2.87 mm. in length and 1.50 mm. in height; an interior cast of the right valve of a smaller specimen also without the outer border, is 2.50 mm. in length and 1.32 mm. in height; in an interior cast of a left valve of the shorter variety of the species also lacking the outer border, the same measurements give 2.34 mm. and 1.31 mm., respectively; in a right valve of the short variety they give 2.34 mm. for the length, 1.32 mm. for the height without the border and 1.50 mm. with the border.

This species is closely allied to *M. incipiens* the only conspicuous difference between the two, as they usually occur, being in their longitudinal dimension. Comparison of their measurements shows that the valves of *M. producta* are always considerably longer than those of *M. incipiens.* In other respects interior casts of the two are essentially alike. As a common but not constant exception we may point out that the dorsal half of the anterior edge usually forms more nearly a right angle with the dorsal edge than in *M. incipiens.* Comparison of specimens that retain any part of the outer border brings out another difference, namely, that this border is flatter in *M. producta* than in the other.

Two varieties are recognized, one relatively longer than the other. No other differences have been observed.

Occurrence.—Same as *M. incipiens.*

Collection.—U. S. National Museum.

MASTIGOBOLBINA RETIFERA n. sp.

Plate LIII, Figs. 1-7

Description.—Two valves of the typical rounded kind have the following dimensions; length 2.20 and 2.37 mm., height 1.58 and 1.75 mm., respectively. The largest seen is about 2.50 mm. in length, the smallest about 2.00 mm.

This species also is more closely allied to *M. incipiens* than to any other now known. It is shorter, more rounded in outline, with more obtuse cardinal angles, shorter hinge, shallower marginal furrow, and less upturned, flatter, outer border than in that species. The inflated upper part of the middle lobe also is more rounded, but the most striking difference pertains to the outer surface of the convex parts. In *M. incipiens* the shell is smooth, in this it is neatly reticulated. This ornament is plainly visible under an ordinary pocket lens. The convexity of the surface as a whole is somewhat less than in either of its associated allies, *M. incipiens* and *M. producta.* The middle lobe, however, is quite as prominent and more rounded than in the other two members of its group.

We know of no other Clinton species with which the present form might be confused. A possible exception is the *Plethobolbina ornata* an Upper Clinton fossil. In that species, however, the surface is minutely punctate instead of finely reticulate, with smaller rounded holes. It lacks also the flagellum, its median lobe is less prominent and undefined on the posterior side, the median sulcus narrower and its dorsal angles more sharply produced.

Occurrence.—Same as *M. incipiens.*

Collection.—U. S. National Museum.

Genus PLETHOBOLBINA new genus

Carapace primitian in aspect, 2.0 mm. to 4.0 mm. in length, strongly convex, with rather narrow flat border, developed chiefly on the anterior side. Valves unisulcate, the sulcus median in position, extending obliquely backward from the dorsal edge about half across the valves. Median lobe merged with the posterior lobe, distinguishable only by a slight swelling just behind the sulcus. Posterior lobe indistinguishably merged in the general convexity of the surface. Anterior lobe essentially as in *Mastigobolbina* except that it is proportionally somewhat larger and less defined and commonly lacks the recurved lash-like extension of the median lobe. Brood pouch, if any, merely adds slightly to the height and convexity of the posterior half.

Genotype.—*Plethobolbina typicalis* n. sp.

One species found in the lower part and four in the upper part of the Clinton group in eastern North America.

It should be observed that a brood pouch has not been positively recognized in *Plethobolbina.* Of four of the five species this may be accounted for on the ground of insufficient material, only a few specimens of each being known. But this explanation seems inadequate in the case of the relatively abundant *P. typicalis.* However, study of many specimens of the latter suggests that the two sexes, though barely distinguishable, are much less different in appearance than is the case in the typical species of *Mastigobolbina.* Critical comparisons seem to establish that some specimens of *P. typicalis* are slightly fuller in the post-ventral part than the others. Probably these slightly more ventricose examples are female individuals of the species.

PLETHOBOLBINA TYPICALIS n. sp.

Plate LII, Fig. 21; Plate LIII, Figs. 28-33

Description.—Length 3.5 to 4.0 mm.; height 2 to 2.25 mm. Disregarding generic characters which it shares with the other species, *Plethobolbina typicalis* is distinguished by its distinct dorsal angles, rather short, oblique and posteriorly sharply defined median furrow, and great thickness of the anterior half, the surface rising slowly to a crested summit located near the middle of the anterior third and then descending abruptly to the border. The border is wide and well defined on the anterior end, but on the ventral and posterior sides until it approaches the hinder dorsal angle it is narrower and less distinct.

The small curved crest near the anterior margin doubtless represents the corresponding recurving part of the " whip-lash " of typical species of *Mastigobolbina.* Commonly it is injured or broken away in freeing the specimens from the stony matrix. A similar feature is developed in extreme manner in *Bonnemaia celsa.* Unless Fig. 32, which is one of several specimens that differ from others in being fuller in the post-ventral region, should prove to be the female form of this species then it is either unknown or the valves of the two sexes are indistinguishable.

Occurrence.—CLINTON. One of the most characteristic, abundant, and geographically widely distributed fossils of the *Mastigobolbina typus* zone. It occurs in the zone near Great Cacapon, W. Va., Six Mile House, Md., Hollidaysburg, Pa., and in sandstone of corresponding age at Big Stone Gap and other places in Virginia and at Clinton, N. Y.

Collection.—U. S. National Museum.

PLETHOBOLBINA ORNATA n. sp.

Plate LIII, Figs. 18-20

Description.—Length, 1.6 mm.; height, 1.05 mm. This species is associated with *Plethobolbina typicalis* but is considerably smaller, its valves are more evenly convex, and their convex surfaces are covered with small, closely arranged punctæ forming a neatly reticulated ornamentation. The posterior furrow is suggested in more definite fashion than in *P. typicalis,* the species showing in this and other respects a decided resemblance to *Mastigobolbina punctata,* in which the posterior furrow is yet very narrow but deeply impressed. Though easily distinguished by the mentioned difference and even though we have found it expedient to place them in distinct genera it is not to be denied that the relations in this case are truly genetic. Nearly the same kind of relation exists between the following *P. cornigera* and *Mastigobolbina trilobata.* However, systematic classification is necessarily more or less arbitrary and artificial, so that such interrelations among closely allied genera are to be expected.

Occurrence.—Clinton. One of the rarer species in the *Mastigobolbina typus* zone, near Hollidaysburg, Pa.

Collection.—U. S. National Museum.

Plethobolbina cribraria n. sp.

Plate LIII, Figs. 23, 24

Description.—Length, 1.5 mm.; height, 0.9 mm. This has the same kind of surface reticulation as *Plethobolbina ornata* but differs in its outline, which is more elongate oval. Its ends also are more nearly equal in height. Further, the small swelling just behind the median sulcus is more prominent and narrower, but the posterior sulcus is no better developed. Other differences are obscurely indicated, but the specimens are too poorly preserved to permit more detailed comparisons.

Occurrence.—Clinton. The types and only known specimens were found at Cumberland, Md., about 57 feet above the top of the underlying Tuscarora sandstone.

Collection.—Maryland Geological Survey.

Plethobolbina cornigera n. sp.

Plate LIII, Figs. 21, 22

Description.—Length, 3.4 mm.; height, 2.0 mm. This is similar in general aspect to *Plethobolbina ornata* but is larger and had a smooth surface. The posterior side of the median sulcus also is sharper.

straighter, more nearly vertical in direction, and extends quite to the dorsal edge. A striking difference is the presence of a short spine or node on the dorsal edge half-way between the median sulcus and the anterior dorsal angle. This node is another feature that reminds of species of *Mastigobolbina* being found in *M. triplicata, M. arguta,* and *M. intermedia.* The whip-lash too is clearly developed. However, on account of the practical absence of the posterior furrow the species must be referred to *Plethobolbina.*

Occurrence.—CLINTON. *Mastigobolbina typus* zone on Wills Creek at Cumberland, Md. Apparently the species is rare, very few specimens and all of them imperfect having been observed.

Collection.—Maryland Geological Survey.

PLETHOBOLBINA SULCATA n. sp.

Plate LIII, Figs. 25-27

Description.—Length, 2.0 mm.; height, 1.5 mm. The specimens on which this species is founded occur in a sandstone whose fossil content has suffered considerable distortion through lateral pressure. Moreover, the texture of the matrix is too coarse to preserve minor details of structure and surface marking. However, the bed belongs to a middle Clinton zone from which better material is not to be expected. This reason and because of the desire to register the Clinton ostracod fauna as fully as the material in hand permits may constitute a sufficient excuse for introducing new species on material that would ordinarily be regarded as unworthy of description.

So far as can be determined *Plethobolbina sulcata* is allied to *P. typicalis,* differing from it mainly in its longer and less steep-sided sulcus. As a result the bilobation of the valves and the convexness of the lobes are both decidedly greater than in *P. typicalis* or in any other species now referred to the genus.

Occurrence.—CLINTON. *Zygobolbina emaciata* zone. Toll-gate at Cove Gap, Tuscarora Mt., 4½ miles northwest of Mercersburg, Pa.

Collection.—U. S. National Museum.

Genus KLŒDENIA Jones and Holl

KLŒDENIA NORMALIS n. sp.

Plate LXI, Figs. 15-19

Description.—Length, 2.0 mm.; height, 1.1 mm. This is a neatly outlined species with nearly equal ends, sharp dorsal angles, and normally developed lobation. The border is well developed on the ends but narrows on the ventral side. In the female the brood pouch has the usual size, form, and position for the genus. It is perhaps somewhat more prominent and more clearly outlined than usual. Though a perfectly typical species of the genus, we have found no exact match for it among the species hitherto published. *Klœdenia smocki* (Weller), an upper Manlius species in New Jersey, is as near as any. In Weller's species the median sulcus is larger and the outlines and profiles slightly different.

Occurrence.—WILLS CREEK FORMATION. Pinto (45 feet above base) and Flintstone, Md. (182 feet above base).

Collection.—Maryland Geological Survey.

KLŒDENIA NORMALIS var. APPRESSA n. var.

Plate LXI, Figs. 20-22

Description.—Length, 1.3 mm.; height, 0.90 mm. Compared with the typical form of the species, variety *appressa* is shorter and has less regularly rounded outlines. Another difference lies in the antero-dorsal quarter, which instead of being neatly convex as in *K. normalis* is slightly concave. There is a notable flattening of the surface also beneath the median lobe. The median sulcus is deep, long, and vertical; the anterior sulcus is likewise deep and curves around the median lobe, which is relatively prominent. The border is well developed on the posterior end but becomes rather indefinite in the antero-ventral region.

Occurrence.—WILLS CREEK FORMATION. Flintstone, Md., 162 and 182 feet above base.

Collection.—Maryland Geological Survey.

KLŒDENIA KENZIENSIS n. sp.

Plate LXI, Fig. 23

Description.—Length, 2.0 mm.; height, 1.1 mm. This species is near *Klœdenia sussexensis*—a basal Denvonian species (Decker Ferry) but the sulci are not so deep and the border not so sharply defined. It differs from *K. normalis* in its less regularly rounded end and ventral sides and high but anteriorly less sharply defined median node. In fact, both of the sulci are shallower.

Occurrence.—MCKENZIE FORMATION. Pinto, Md., 100 feet beneath top.

Collection.—Maryland Geological Survey.

KLŒDENIA CACAPONENSIS n. sp.

Plate LXI, Figs. 24, 25

Description.—Length, 1.6 mm.; height, 1.0 mm. Similar to *Klœdenia normalis* but is relatively a shorter and higher form, with larger and more produced dorsal angles, more nearly vertical rectangular ends, straighter furrows, ventrally obsolete border, and in general greater convexity of valves. The brood pouch is very large but hardly so prominent or so clearly outlined as in *K. normalis.*

Occurrence.—CLINTON. (*Drepanellina clarki* zone). One and one-half miles east of Great Cacapon, W. Va., and Lakemont, Pa.

Collection.—U. S. National Museum.

KLŒDENIA LONGULA n. sp.

Plate LXI, Figs. 30, 31

Description.—Length, 1.5 mm.; height, 0.75 mm. Characterized by its longish form, subequal ends, the anterior being but slightly lower than the posterior, and shallow posterior sulcus. The latter is very faintly continued across the ventral half, thus suggesting *Zygobeyrichia,* toward which type it is trending. It occurs, as shown in the figures, by thousands on certain bedding planes in the lower Wills Creek formation at Flintstone. Close study of these specimens shows how persistent these ostracoda are in minor details.

Occurrence.—WILLS CREEK FORMATION, lower part. Flintstone, Md.

Collection.—Maryland Geological Survey.

KLŒDENIA OBSCURA n. sp.

Plate LXI, Figs. 26-29

Description.—Length, 2.5 mm.; height, 1.75 mm. The outline itself is distinctive in this species, but there are other peculiarities even more so. Among these is the comparatively low convexity of the valves, the exceeding shallowness and indefiniteness of the furrows and consequently also the lowness and lack of definition of the lobes and the thick edges with overhanging border. So far as the type of lobation can be determined it reminds of species referred to *Mastigobolbina.* The middle lobe might be described as obscurely inverted, pear-shaped, its narrow end extending into the ventral half of the valve. Then there is a low posterior ridge essentially as in *M. virginia* and other species of its genus. In our opinion this ostracod is really a truer ally of *Mastigobolbina* than of *Klœdenia,* but on account of the general obscurity of its characters and because the only lobe about which one may be certain is quite obviously the homologue of the one between the two sulci in *Klœdenia* we have provisionally elected to refer it doubtfully to the latter genus.

Occurrence.—CLINTON. Top of Frankstown ore seam, one-half mile northwest of Frankstown, Pa.

Collection.—U. S. National Museum.

Genus WELLERIA new genus

Form and lobation of valves of males essentially as in *Klœdenia* from which it differs in the character of the ventral swelling in the female. This instead of forming a definitely outlined large subovate and prominent pouch covering the posterior two-thirds of the ventral slope, forms a low undefined swelling taking in nearly or quite the whole of the ventral two-thirds of the valves. At the base it is compressed and slightly overhangs the ventral edge.

Genotype.—*Welleria obliqua* new species.

This interesting generic type, named in honor of Professor Stuart Weller, is represented by an abundance of specimens in the Tonoloway limestone of Maryland and neighboring states.

WELLERIA OBLIQUA n. sp.

Plate LV, Figs. 6-10

Description.—Average length, 3.00 mm.; height, 2.00 mm. A large ostracod short and high with moderately convex valves, sharp dorsal angles, with curved ventral outline, vertical anterior side more obtusely angular posteriorly, the form as a whole therefore swings obliquely backward; border thick at and near the angles narrowing thence to the ventral side where it is always appreciable but usually not a conspicuous feature. Ventral edge thick, descending abruptly from the border to the contact edge. The ventral swelling in the female undefined above, low and very extensive, overhanging the ventral edge slightly. On well-preserved specimens the surface of this swelling shows a number of sparsely arranged small punctæ.

Occurrence.—TONOLOWAY LIMESTONE. Common throughout the formation especially in the lower part at Keyser, W. Va., Grasshopper Run, near Hancock, and other Maryland localities.

Collection.—Maryland Geological Survey.

WELLERIA OBLIQUA var. LONGULA n. var.

Plate LV, Figs. 11, 12

Description.—Length, 2.2 mm.; height, 1.2 mm. With the typical form of the species occurs fewer specimens of longer valves with less convexly curved outlines and more regularly developed border. These are provisionally distinguished as a variety under the name *longula*.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Keyser, West Virginia, Pinto and various other Maryland localities.

Collection.—Maryland Geological Survey.

WELLERIA OBLIQUA var. BREVIS n. var.

Plate LV, Fig. 13

Description.—Length, 2.00 mm.; height, 1.25 mm. This variety is distinguished by its dorsally converging terminal outlines and relatively short form.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Keyser, West Virginia, Pinto and various other Maryland localities.

Collection.—Maryland Geological Survey.

Genus KYAMMODES Jones

Male valves of *Kyammodes* differ from those of *Welleria* and *Klœdenia* which are regarded as related genera, in having two short and small lobes on the dorsal slope besides the pair of larger ones on either side of the median sulcus. The latter as usual in *Klœdenia* and *Welleria* is longer than the other sulci but in *Kyammodes* the lobation of the valves is on the whole more strictly confined to the dorsal slope than in the mentioned related genera. There seem also to be certain peculiarities about the overlapping of the valves on the ventral edge that are not yet fully understood. The female form of the type *K. whidborni* is unknown but in *Klœdenia Kiesowi* Krause which seems to have all the characteristic features of *Kyammodes* the female has a very large strongly convex pouch, larger than usual in *Klœdenia* and quite different from the undefined swelling of the valves in the female form of *Welleria*.

There are two species in the Silurian of Maryland that are quite certainly congeneric with at least *K. kiesowi*.

Genotype.—*K. whidborni* Jones from the Devonian of England.

KYAMMODES SWARTZI n. sp.

Plate LV, Figs. 14-16

Description.—Average valve, length, 1.66 mm.; height, 1.25 mm. Distinguished from *Kyammodes tricornis* and the European *K. kiesowi* by its shorter sulci and subpentagonal form. The right valve as usual in the genus, has the ventral slope near the edge broadly concave but projects conspicuously beyond the line of a regular curve. This gives the obscurely five-sided outline that is characteristic of the species and a very uncommon feature in ostracoda. In the left valve the concavity in the ventral slope is practically wanting, the profile being merely somewhat straightened before bending down to the edge. Obviously, the right valve overlaps the free edges of the left.

Occurrence.—TONOLOWAY LIMESTONE. Lower part (128 feet above base), Grasshopper Run, near Hancock, Maryland.

Collection.—Maryland Geological Survey.

KYAMMODES TRICORNIS n. sp.

Plate LV, Figs. 1-5

Description.—Length, 2.00 mm.; height, 1.30 mm. *K. tricornis* is characterized by its semiovate outline, nearly equal ends, acuminate dorsal angle and subcarinate lobes. The two median lobes project beyond the dorsal edge and the posterior one is much smaller and as it nears the dorsal side curves distinctly forward. The small anterior lobe seen in the other species of genus is barely distinguishable as a low thin curved ridge in this. The anterior and median sulci, especially the latter, are deep and longer than usual in this genus extending nearly or quite halfway across the valves. In the male form the ventral border, though indefinitely outlined by a mere concavity is nevertheless a conspicuous feature. In the middle its edge stands well above the contact edge. In the female it is covered by a large strongly convex oval pouch two-thirds of which lies behind the middle of the valve.

This species is closely allied to *K. kiesowi* (Krause) but comparison with authentic males and females of that European species proves they are not strictly the same.

Occurrence.—MCKENZIE FORMATION. 77 and 82 feet below the top at Flintstone, Maryland.

Collection.—Maryland Geological Survey.

Genus ZYGOBEYRICHIA Ulrich

Distinguished from related genera by the partial or complete obsolescence of the posterior lobe and the excessive development of the ventral junction of the median and anterior lobes.

Genotype.—*Zygobeyrichia apicalis* Ulrich.

ZYGOBEYRICHIA VENTRIPUNCTATA n. sp.

Plate LIV, Figs. 15-18

Description.—Average length, 3.20 mm.; height, 2.00 mm. *Zygobeyrichia ventripunctata* is characterized by the strong punctæ on the ventral two-thirds of its lobes. These are somewhat wide-spread in the male but on the female the brood pouch is thickly covered by them. Both are easily recognized by this and other characters clearly shown in the figures.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, West Virginia, Pinto and other localities in Maryland. Manlius limestone, Schoharie County, New York.

Collection.—Maryland Geological Survey.

ZYGOBEYRICHIA REGINA n. sp.

Plate LIV, Figs. 1, 2

Description.—Average length, 3.0 mm.; height, 2.0 mm. Associated with *Zygobeyrichia ventripunctata* is an abundant closely related species of about the same size and general characteristics but differing in lacking the punctations of the ventral two-thirds. To this splendid form the specific name *regina* is applied.

Z. regina is also related to the associated *Z. tonolowayensis* but differs in its straighter ventral edge and stronger border.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, West Virginia.

Collection.—Maryland Geological Survey.

ZYGOBEYRICHIA TONOLOWAYENSIS n. sp.

Plate LIV, Figs. 3-5

Description.—Length, 2.8 mm.; height, 1.8 mm. Related to and associated with *Zygobeyrichia regina* but differs in its more convex ventral outline.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, West Virginia, Pinto and other localities in Maryland.

Collection.—Maryland Geological Survey.

ZYGOBEYRICHIA INCIPIENS n. sp.

Plate LIV, Figs. 13, 14

Description.—Length, 1.75 mm.; height, 1.2 mm. Differs from the other species of the genus and most of those of *Klœdenia* in the ventral obsolescence of the border. The associated *Z. ventricornis* is distinguished at once by the large ventral node and greater height of anterior half. The posterior edge is uncommonly straight and nearly vertical in its upper three-fourths.

Occurrence.—WILLS CREEK FORMATION. Forty-five feet above base at Pinto, Maryland.

Collection.—Maryland Geological Survey.

ZYGOBEYRICHIA VENTRICORNIS n. sp.

Plate LIV, Figs. 6-8, 11

Description.—Typical form, length, 2.25 mm.; height, 1.3 mm. This has passed out of the typical *Klœdenia* type of structure into the province of *Zygobeyrichia* the posterior lobe being at least partially separated below from the base of the middle lobe. Under *Zygobeyrichia* it is distinguished by the node near the base of the middle of the ventral slope. This is somewhat broken down in the smaller of the left valves lying together on the specimen figured.

Occurrence.—WILLS CREEK FORMATION. Pinto (45 feet above base) and Flintstone, Maryland (182 feet above base). A later appearance of the species occurs in the upper Tonoloway at Keyser, West Virginia.

Collection.—Maryland Geological Survey.

ZYGOBEYRICHIA VENTRICORNIS var. OBSOLETA n. var.

Plate LIV, Figs. 9, 10

Description.—The Tonoloway limestone also contains two supposed mutations of *Z. ventricornis,* both lacking the small ventral node. One of these is a little longer and the other a little shorter than the typical form.

Occurrence.—WILLS CREEK FORMATION. One hundred and eighty-seven feet above the base at a locality, 3 miles west of Hancock, Maryland.

Collection.—Maryland Geological Survey.

ZYGOBEYRICHIA MODESTA n. sp.

Plate LIV, Fig. 12

Description.—Length, 1.0 mm.; height, 0.80 mm. A small form whose structural relations seem nearer *Z. ventricornis obsoleta* than to any other. It differs however, in addition to its smaller size, in its narrower anterior end and relatively greater convexity of the ventral slope. There is a very faint continuation of the posterior sulcus across the ventral half of the valve suggesting *Zygobeyrichia.* It agrees in this respect with *Klœdenia longula* but differs from it in its narrower anterior end and relatively shorter and more oblique outline.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 128 feet above base at Grasshopper Run, near Hancock, Md.

Collection.—Maryland Geological Survey.

Subfamily DREPANELLINAE

Genus DREPANELLINA new genus

Drepanellina evidently was evolved out of the Ordovician *Drepanella.* The valves of the male forms of the new genotype in fact are more like those of the oldest species of that genus, as for instance the middle Stones River *Drepanella ampla,* than the Richmond representatives of that genus. Except that the anterior lobe is well developed and confluent with the ventral part of the marginal ridge, there is no satisfactory difference between these Silurian species and their supposed Ordovician ancestors. But even the anterior ridge and in fact the marginal ridge as a whole is subject to considerable modification in *Drepanellina.* It is weakly developed and certainly but obscurely defined in *D. simplex* and *D. confluens.* In the former of these both the anterior and the posterior ridge is sunken, close to the dorsal edge, beneath the level of dorsal angles. In the males of the latter the posterior ridge is well and more normally developed but the anterior ridge is almost completely merged with the antero-median lobe whereas the ventral ridge is so thick and low as scarcely to suggest the ventral ridge of *D. clarki* and *D. modesta.* Indeed, *D. confluens* presents a suspicious resemblance to *Klœdenia.* Under the circumstances *Drepanellina* should be regarded as a type of varying aspect, the variability probably being caused by instability of generic characters in the decadence of an old genus. Compared with *Drepanella,* which itself is most variable in the lobation of its valves, the new Silurian genus *Drepanellina* is distinguished mainly by the development of a broad and indefinitely outlined brood pouch in the female. This swelling affects the posterior two-thirds of the ventral ridge in *D. clarki, D. modesta* and *D. simplex* and the post-ventral three-fifths of the ventral half in *D. confluens.*

D. simplex suggests *Kyammodes,* while *D. confluens* makes one think of *Klœdenia.*

Genotype.—*Drepanellina clarki* n. sp.

DREPANELLINA CLARKI n. sp.

Plate LVI, Figs. 10-13

Description.—Length, 4.0 mm.; height, 2.3 mm. The sharply defined, high subcarinate marginal ridge and two vertically disposed high median lobes, the posterior of which is the broader and the extremities of which project beyond the dorsal edge and the subequal ends and sharp dorsal angles impart an unmistakable aspect to the male valves of this fine species. The female differs only in the much greater development of the ventral ridge. On its overhanging under side the pouch is finely striated.

The specific name of this splendid ostracode is in memory of Dr. William Bullock Clark, late state geologist of Maryland, to whose energetic efforts science owes the initiation of the series of paleontologic reports of which this is one.

Occurrence.—CLINTON. The principal guide fossil of the *Drepanellina clarki* or upper zone at Cumberland and other localities in Maryland, and Lakemont, Hollidaysburg, McKees farm, 7 miles west of Lewiston, etc., Pennsylvania.

Collection.—Maryland Geological Survey.

Drepanellina modesta n. sp.

Plate LVI, Figs. 1, 2

Description.—Length, 2.8 mm.; height, 1.8 mm. Differs from *D. clarki* mainly in the fact that the median lobes are somewhat lower and do not quite reach the dorsal edge. So far as known it does not attain the size of that species. The relations in this respect are indicated by the illustrations.

Occurrence.—Clinton. *Drepanellina clarki* zone at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

Drepanellina? simplex n. sp.

Plate LVI, Fig. 3

Description.—Length, 0.95 mm.; height, 0.60 mm. This is a much smaller species than either *D. clarki* or *D. modesta* and more nearly semi-ovate in outline. It differs especially in the greater convexity of the valves and the resulting immersion of the marginal ridge. The dorsal continuations of the immersed ridge, that is, the parts that correspond to the anterior and posterior ridges in *D. clarki,* are exceedingly weak and sunken beneath the level of the dorsal angles. The pair of median lobes, on the contrary, stand out very prominently.

This is perhaps more than a suggestion of *Kyammodes* in this species, but until whole specimens shall have been found we prefer to classify it as above provisionally.

Occurrence.—Clinton. (*Drepanellina clarki* zone), Lakemont, Pennsylvania.

Collection.—U. S. National Museum.

Drepanellina confluens n. sp.

Plate LVI. Figs. 7-9

Description.—Length, 3.0 mm.; height, 1.75 mm. Despite the general resemblance to species of *Klœdenia* this species is believed to be a closer genetic ally of *Drepanellina clarki.* It is thought to be merely a case of almost complete confluence of the two anterior lobes and consequent elimination of the anterior sulcus. The ventral ridge also is practically effaced in the broader convexity of the ventral half. However, the edge is thick and descends vertically from the edge of the ventral and lateral slopes, as in typical *Drepanellina*. In the female, too, the brood pouch is undefined low and otherwise much the same as in *D. clarki*. The only difference in this feature is that the anterior limits of the pouch lie somewhat nearer the midlength. As a species, of course, these distinctions are sufficiently conspicous to render its identification and separation comparatively easy.

Occurrence.—Mt. Wissick, Temiscouta Lake, Quebec, Canada.

Collection.—U. S. National Museum.

DREPANELLINA VENTRALIS n. sp.

Plate LVI, Figs. 5, 6

Description.—Length, 1.70 mm.; height, 1.00 mm. Though having the essential characters of *Klœdenia* this species makes one think of other genera before finally deciding that it does not fit as well in any other. The peculiar transverse elevation near the middle of the ventral side and the suggestion of its continuance in the posterior lobe brings *Drepanella* with its sickle-shaped marginal ridge to mind. Besides, the sulci extend rather farther across the valves than usual in *Klœdenia*. However, they are somewhat shorter in the variety. For the present then the classification adopted seems the least objectionable. The variety occurring with the typical form of the species differs in having inturned dorsal angles, a shorter hinge and the transverse ventral ridge farther removed from the edge.

Occurrence.—CLINTON. *Drepanellina clarki* zone, 34 feet above Keefer sandstone at Rose Hill, Maryland.

Collection.—Maryland Geological Survey.

DREPANELLINA CLAYPOLEI n. sp.

Plate LVI, Fig. 4

Description.—Length, 1.85 mm.; height, 1.00 mm. Distinguished from all of the species now referred to *Drepanellina* by its oblique shape, prominent sharpness of the anterior dorsal angle and smallness of the antero-median node. The ventral ridge and node is more prominent than in *D. ventralis* and the posterior broken continuation of the marginal ridge is better developed. *D. claypolei* may be regarded as intermediate between *D. ventralis* and *D. clarki* and through the former which it precedes in age possible connection with *Kyammodes* and such species of *Zygobeyrichia* as *Z. ventricornis* is strongly suggested.

Occurrence.—CLINTON. Juniata County, Pennsylvania. Specimen collected by Professor E. W. Claypole and received from him many years ago.

Collection.—U. S. National Museum.

Family BEYRICHIIDAE

Genus BEYRICHIA McCoy

BEYRICHIA EMACIATA n. sp.

Plate LXIII, Fig. 28

Description.—Length, 1.5 mm.; height, 1.0 mm. The valves in this species suggest emaciation, the thickness being uncommonly low and the anterior and posterior ridges narrower, the furrows being correspondingly wide. The median lobe extends to the dorsal edge, long elliptical in form and drawn out ventrally to form a thin loop connecting it with the base of the anterior lobe. The junction of the anterior and dorsal sides is rectangular, the posterior part of outline decidedly rounded. The valves on the whole are unusually high in comparison with the length.

This combination of characters is not exactly matched by any of about 100 species of this genus recognized by us. With possibly a single exception that we know from the Richmond of Ohio, this is the oldest species of the genus. This fact excuses the establishment of a new species on material that is not in a satisfactory state of preservation.

Occurrence.—CLINTON. Fifty-seven feet above the Tuscarora sandstone along Wills Creek, Cumberland, Maryland.

Collection.—Maryland Geological Survey.

BEYRICHIA KIRKI n. sp.

Plate LXIII, Figs. 29, 30

Description.—Length, 2.0 mm.; height, 1.40 mm. Characterized by its relatively narrow anterior end, long hinge, angular dorsal extremities, the anterior especially being drawn out, and irregularly nodose surface. The posterior ridge or lobe is low in its ventral half but rises into a prominent node at the dorsal margin. A similar node occurs at the dorsal extremity of the inner side of the anterior lobe. The latter is of irregular form, wide and high below, low in its middle and antero-dorsal parts. The middle lobe is spindle shaped being drawn out dorsally, and ventrally, the latter part narrowing like the neck of a gourd and curving forward to join the base of the anterior lobe. The border as usual has a thickened rim, the concave space within it being wider at the dorsal angles and in the post-ventral part but narrows decidedly in the lower part of the anterior side. The radial striations are practically wanting.

The specific name is in honor of Dr. Edwin Kirk of the U. S. Geological Survey, who collected most of the specimens used in the above description.

Occurrence.—CLINTON. Lower part at Lakemont, Pennsylvania.

Collection.—U. S. National Museum.

BEYRICHIA LAKEMONTENSIS n. sp.

Plate LXIII, Fig. 25

Description.—Length, 1.9 mm.; height, 1.25 mm. *B. lakemontensis* is allied to and commonly associated with *B. kirki* with which it was first confused. On more careful study we find many small differences: the hinge-line is shorter, the rim thinner, the anterior dorsal angle is obtuse instead of sharply angular and produced, the nodes and irregularities in surface contour while similar in position are less prominent; and in other features that are best appreciated by comparison of the illustration. Of these other differences one may be pointed out, namely, the frill is radially marked by waves rather than striations.

Although these characters tend toward the normal among species of *Beyrichia* there is none with which we are acquainted that is a closer ally than *B. kirki.* This is true particularly so far as American species are concerned.

Occurrence.—CLINTON. *Mastigobolbina typus* zone at Lakemont and other localities near Hollidaysburg, Pennsylvania, and in the corresponding beds at Great Cacapon, Maryland.

Collection.—U. S. National Museum.

BEYRICHIA MESLERI n. sp.

Plate LXIII, Figs. 17-20

Description.—Length, 1.50 mm.; height, 1.10 mm. This species occurs with and is likely to be confused with *B. moodeyi.* However, it seems constantly a smaller form and with well-preserved material is distinguished at once by its lack of surface punctæ or reticulation. Another constant difference lies in the presence of the low nodes at the dorsal extremities of the anterior and posterior lobes, a feature that is wanting in *B. moodeyi.* Further the anterior sulcus is not so oblique and usually at least is also narrower than in the associated species. Finally, there is a shallow groove in the outer slope of the anterior lobe that is wanting in *B. moodeyi.* Several of these differentiating features, notably the absence of surface ornament, the nodes on the dorsal extremities of the anterior and posterior lobes and the furrow on the antero-dorsal slope of the anterior lobe, remind sufficiently of *B. lakemontensis* and somewhat less of *B. kirki* to impress us with the conviction that the genetic relations of *B. mesleri* are with those species rather than with *B. veronica* and *B. moodeyi.* It is too clearly distinct from the former pair of species to require detailed comparison.

The specific name is in honor of Mr. R. D. Mesler of the U. S. Geological Survey.

Occurrence.—MCKENZIE FORMATION. Upper part, 77 and 82 feet below top at Flintstone, Maryland.

Collection.—Maryland Geological Survey.

BEYRICHIA TONOLOWAYENSIS n. sp.

Plate LXIII, Fig. 26

Description.—Length, 1.30 mm.; height, 1.00 mm. This is another derivative of *B. kirki* and one that followed *B. mesleri.* Its outline is much more oblique than that of the latter and also more so than in the former; and its length is relatively less than in either though particularly in *B. kirki.* It differs again from both in its narrower anterior lobe. The two thin carinæ on either side of the ventral half of the anterior lobe are characteristic. The wide, radially striated ventral border suggests its nearness to *B. mesleri.*

Occurrence.—TONOLOWAY LIMESTONE. Lower part, 128 feet above base at Grasshopper Run near Hancock, Maryland.

Collection.—Maryland Geological Survey.

BEYRICHIA VERONICA n. sp.

Plate LXIII, Figs. 21-24.

Description.—Length, 0.90 mm.; height, 0.65 mm. A well-characterized species resembling in general the McKenzie species *B. moodeyi.* It differs in having a coarser surface reticulation, in the greater curvature and decidedly lesser obliquity of the anterior sulcus, its narrower posterior sulcus which is not cut off at the base of the median lobe as in that species but continues on into the post-ventral depression which affects more of the area wherein the ventral extremities of the lobes commonly join than usual in species of this section of the genus. The posterior lobe, therefore, is more definitely separated below from the other lobes than in *B. moodeyi.*

B. veronica is an altogether normal species of the typical *B. klœdini* group of the genus. Three or four European species might be cited as close allies but detailed comparisons of specimens and illustrations have satisfied us of the specific distinctness of this Appalachian species. Among the American species its nearest relative in addition to *B. moodeyi* mentioned above is *B. granulifera* Hall which is one of the rare members of the fauna of the Waldron shale of Indiana. Regarding the relations to the latter, one would hardly suspect their actual closeness judging it solely from the description and figures published by Hall and the name *granulifera* applied to it. However, investigation of the original type now preserved in the American Museum of Natural History has brought out the fact that the surface is not granulose as stated and figured by its author but finely reticulated as in *B. veronica* and *B. moodeyi.* In view of this fact, the question arises whether *B. waldronensis* Ulrich and Bassler is not founded on a specimen of the misnamed *B. granulifera.*

B. veronica differs from *B. moodeyi* and the Waldron species in the lesser development of the ventral part of the posterior lobe and its narrower, less distinctly striated but thicker rimmed border. Other differences may be observed on critical comparison of the illustrations. For instance, the base of the median lobe and its junction with the base of the anterior lobe is more depressed. The reticulate surface ornament is also of a coarser pattern in *B. veronica.*

Occurrence.—CLINTON. *Drepanellina clarki* zone at Cumberland, Maryland, and Hollidaysburg and McKees farm, 7 miles west of Lewiston, Pennsylvania.

Collection.—Maryland Geological Survey.

BEYRICHIA MOODEYI Ulrich and Bassler

Plate LXIII, Fig. 27.

Beyrichia moodeyi Ulrich and Bassler, 1908, Proc. U. S. Nat. Mus., vol. xxxv, p. 285, pl. xxxvii, fig. 8.

Description.—Length, 1.50 mm.; height, 1.00 mm. This species is probably the American form referred to *Beyrichia maccoyiana* by Jones. It is distinguished from that European species by the greater isolation of the median lobe and the very finely punctate surface of the lobes. Apparently derived out of Upper Clinton *B. veronica* from which it differs in the obliquity of the anterior sulcus, the minor constriction at the base of the middle lobe and lesser separation of the ventral extremity of the posterior lobe from adjacent parts of the middle and posterior lobes. The surface reticulation also is of a finer pattern and the average size of the carapace somewhat greater.

Occurrence.—McKenzie formation. One and one-half miles east of Great Cacapon, West Virginia, Cumberland, Maryland, and 237 feet below top at Pinto, Maryland.

Collection.—Maryland Geological Survey.

BEYRICHIA HARTNAGELI n. sp.

Fig. 27. 3-5

Description.—Intermediate in size and also in its outline between *B. veronica* and *B. normalis,* from both of which it differs in its narrower and obtusely carinated posterior lobe and uncommonly thick, semiglobular median lobe. The frill or border is rather wide, radially striated, and distinctly concave. The surface marking is by small, closely arranged punctæ as in the mentioned species, but the pits are so shallow and obscure that the surface in some specimens appears quite smooth. A more important and also more striking difference is observed in comparing females. In those of *B. veronica* and *B. normalis* the brood pouch is almost round, whereas in *B. hartnageli* it is decidedly ovate and also much larger.

This species is introduced here mainly to help in showing that the ostracod fauna of the Irondequoit limestone of western New York is not strictly comparable with that of any Appalachian Clinton zones. The senior author collected at least six species of Ostracoda, among them this *Beyrichia,* out of a block of Irondequoit limestone found about 8 miles east of Lockport. The other species comprise one of *Klœdenella,* one of *Dizygopleura* (allied to *D. proutyi* and *D. pricei* of the *Drepanellina clarki* zone but a clearly distinct new species), a *Thlipsura* and two species of *Bythocypris.* Except the last, which are too simple in structure to be of value in stratigraphic correlation, none of these Ostracoda is precisely like any of the Silurian species found in Maryland. The *Beyrichia hartnageli* is perhaps as near, if not more closely related, to *B. lakemontensis,* a species of the *Mastigobolbina typus* zone, than to either of the two species of the genus found in the overlying *Drepanella clarki* zone. As for the new *Dizygopleura,* it might well represent an antecedent stage in the development of a species like *D. pricei*. In view of these considerations we feel warranted in suggesting the possibility that the Irondequoit limestone of New York falls into the Maryland section at the horizon of the Keefer sandstone.

Occurrence.— IRONDEQUOIT LIMESTONE. Near Lockport, N. Y.

Collection.—U. S. National Museum.

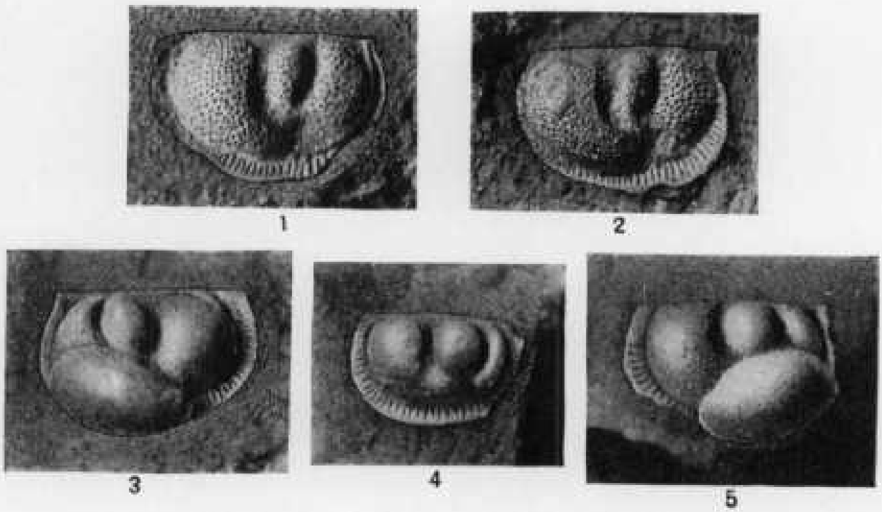

FIG. 27.—ILLUSTRATING THE GENUS BEYRICHIA.

1, 2. *Beyrichia normalis* new species. Two left valves, ×20. Clinton (*Drepanellina clarki* zone) McKees farm, 7 miles west of Lewiston, Pennsylvania.
3-5. *Beyrichia hartnageli* new species. 3. Right valve, female, ×20. 4. Left valve, male, ×20. 5. Left valve, female, ×20. Irondequoit limestone, 8 miles east of Lockport, New York.

BEYRICHIA NORMALIS n. sp.

Fig. 27. 1, 2

Description.—Associated with *B. veronica* at McKees, Pa., there is another reticulated species. It attains a larger size than *B. veronica* and differs further in its relatively shorter form and much more rounded and very slightly projecting antero-dorsal angle. These characters bring it into even closer alliance with *B. waldronensis*, with which, indeed, we were at first inclined to unite these specimens. However, on closer comparison they were found to differ from the Waldron species in being relatively shorter, more equal-ended, with the posterior lobe longer, the median lobe narrower and more deeply separated from the posterior lobe. Moreover, the frill is much narrower and differently oriented with respect to the plane of the valves.

Occurrence.—CLINTON, *Drepanellina clarki* zone, McKees farm, 7 miles west of Lewiston, Pa.

Collection.—U. S. National Museum.

Genus DIBOLBINA new genus

Widely frilled Beyrichiidæ in which the median lobe is almost completely merged with the posterior lobe by great shallowing and practical elimination of the posterior sulcus. However, the median lobe is still indicated by a small prominence located nearly in the middle of the valves excluding the frill. Just in front of it is a fairly deep curved sulcus or depression that fails to reach the dorsal edge and on the opposite side passes into a much shallower post-ventral depression. In the females the latter is covered by the inner half of a semiglobose brood pouch, the outer half lying on the frill.

This new genus is at present represented by only two species, both found in the Tonoloway limestone—the youngest formation of the Silurian system in Maryland. Their genetic relations to other ostracoda are somewhat obscure, because they remind in one or another respect of several widely differing generic types. The general aspect, with particular reference to the wide frill, elongate form and simple lobation, suggests *Eurychilina.* The body of the valves reminds in its curved furrow of the unisulcate species of *Ctenobolbina* and also of species now referred to *Entomis.* But these seem to be mere resemblances and not, we are convinced, indicative of truly close relationships.

Decadence of the stock of typical *Beyrichia* had set in when these late Silurian Dibolbinas existed; and no unquestionable representative of that genus survived into the Devonian. Descendants there were and in considerable number and variety too, but all of them had sustained striking modifications in important structural features.

It is interesting to observe how these newer Devonian modifications of the typical Silurian Beyrichian stock harked back to pre-Silurian facies and stages in the evolution and development of the family. One *Drepanellina* reminds of the Ordovician *Drepanella,* others strongly suggest *Ctenobolbina,* typically also an Ordovician genus, still others recall *Eurychilina.*

Now, something of similarly regressive or atavistic nature happened in the evolution of *Dibolbina.* That this type really was derived out of typical *Beyrichia* and not out of either *Entomis, Ctenobolbina* or *Eurychilina* is strongly indicated by its retention of certain features that are strictly characteristic of the first but wanting in all of the last, namely, (1) the shape of the anterior lobe; (2) the delicate ridge on the antero-ventral slope of the anterior lobe the like of which is not uncommon in *Beyrichia* (*e. g., B. tonolowayensis*) but hardly known among the other possible relatives; (3) the depression in the ventral slope behind the midlength than which there is nothing more characteristic of *Beyrichia;* and (4) the semiglobular form of the brood pouch. Presumably in the ontogeny of *Dibolbina* only these characters attained typical Beyrichian stages, other features halting at various larval stages.

Genotype.—*Dibolbina cristata.*

DIBOLBINA CRISTATA n. sp.

Plate LXIII, Figs. 13-15

Description.—Length with frill, 1.80 mm.; height, 1.00 mm. The specific peculiarities of this species are the delicate crest-like ridge on the antero-ventral slope of the anterior lobe, the rounded posterior side, and the obtusely angular posterior termination of the hinge.

Except the following species no other ostracode is known in the Silurian rocks of America or elsewhere that could possibly be confused with this species.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, West Virginia, Pinto and other localities in Maryland.

Collection.—Maryland Geological Survey.

DIBOLBINA PRODUCTA n. sp.

Plate LXIII, Fig. 16

Description.—Length with frill, 1.40 mm.; height, 0.80 mm. This species is distinguished from *D. cristata* by its longer hinge, the dorsal half of the posterior end being rectangular instead of incurved and the anterior extremity of the hinge even more produced; second, by the presence of a low crescentically curved ridge behind the acuminate anterior extremity; third the slightly greater convexity of the ventral half of the anterior lobe; and fourth by the absence of the antero-ventral crest of that species.

Occurrence.—TONOLOWAY LIMESTONE. Lower part (128 feet above base) at Grasshopper Run near Hancock, Maryland.

Collection.—Maryland Geological Survey.

Family KLOEDENELLIDAE new family

The genus *Klœdenella* was established by the writers in 1908.[1] At the same time the subfamily Klœdenellinæ, comprising besides *Klœdenella* the Carboniferous genera *Beyrichiopsis, Beyrichiella, Jonesina,* and *Kirkbyina,* was proposed. Measured against the present state of information our conception of at least the Silurian and early Devonian representatives of the subfamily or rather family, as we now prefer to view it, was far from adequate. We knew nothing of the astounding wealth of slightly differentiated species and varieties or mutations whose small shells now occur by millions, packing many of the thin limestone layers in the McKenzie, Wills Creek, and Tonoloway formations in Maryland and adjoining states. The great majority of these ostracodal remains, especially those in the McKenzie formation, belong to this family. Although many different forms have been determined and are here illustrated, in nearly all cases for the first time, the fulsome material in hand is still far from exhausted. Doubtless many other distinguishable forms will reward further investigation. However, enough of them have been studied and discriminated to

[1] Proc. U. S. Nat. Mus., vol. xxxv, p. 317, 1908.

make them of great value in definitely recognizing and correlating the major zones of the Silurian deposits in the middle Appalachian region.

Very few of the species range beyond the limits of the formation in which they occur. Indeed, most of them are confined to either the lower or the upper part of the formation. The exceptions, even, are commonly sufficiently different in their successive stratigraphic occurrences to enable one to decide which are earlier and which later manifestations of the particular species. Such closely discriminated forms when found in areas outside of Maryland should make very trustworthy correlation criteria.

In the original description of *Klœdenella* (*loc. cit.*) it was recognized that the genus is divisible into two groups. In the first, comprising the genotype *K. pennsylvanica,* the posterior and median furrows are short and the anterior one either wanting or more or less well developed. In the second group, of which *Beyrichia halli* Jones was cited as a good example, the posterior and anterior furrows are subequal and so long that they extend nearly or quite across the valve. In the light of the much larger specific representation of Klœdenellidæ now available there is ample warrant for the statement that these two groups are for the greater part perfectly natural and really of higher systematic value than we believed in 1908.

With the present great increase in the number of species that would fall under *Klœdenella* as conceived by us in 1908 it follows quite naturally that restriction of that name to some natural and well-characterized group of forms should now be advocated. But, as usual, the separation of the species into natural generic groups is no easy matter. The mutation of the species and their subsequent development is never along regular and sharply defined lines. Except the groups are made very small it is impossible to avoid all artificiality in their classification. There is certain to be some real or at least apparent overlapping and interfingering of relationships. Besides, genera of many species are not developed out of a single root but all are more or less polyphyletic in origin.

In *K. pennsylvanica,* the genotype, we have a fairly definite combination of characters. Seven of the following Silurian species conform with reasonable fidelity to its essential features. In all of them the anterior sulcus is either wanting entirely or barely suggested by a slight depression in the ventral slope. So far the composition of the restricted genus is clearly indicated. The uncertainties and troubles begin when we take up species like those to which the specific names *intermedia, micula,* and *asymmetrica* have been given. In the first the anterior sulcus is still entirely wanting but the outer side of the part that would correspond to the anterior lobe if the anterior sulcus were developed is clearly defined by a curved or nearly straight depression in the anterior slope. In this species the anterior pair of lobes as developed in the "quadrijugate" types of Klœdenellidæ is merged in a single correspondingly broad lobe. In the second and third species the anterior furrow is incompletely and shallowly developed, partially setting off a narrow anterior lobe. Finally, there is the species *loculata* in which the anterior sulcus is represented by a large and deep rounded depression. From the conditions obtaining in species *micula* and *asymmetrica* we pass then gradually through species *subdivisa* and *concentrica* to the *subquadrata* in which quadrilobation is clearly developed.

The difference between those species like *K. pennsylvanica* in which only the posterior half of the carapace is sulcated and those others like the species *clarkei* in which the anterior half as well as the posterior is divided into two lobes is so striking that we were inclined already in 1908 to regard them as warranting their classification under distinct generic names. The intention was then abandoned solely because the extremes seemed to be linked together by transitional forms. Now, however, since the species of the family have greatly increased in number we carry out not only the original desire for two genera but we feel constrained to institute a third also closely allied generic group for a type of structure that was not represented in our collections when *Klœdenella* was proposed in 1908. In accord with these conclusions the new generic term *Dizygopleura* is proposed for the group of quadrilobate species and *Euklœdenella,* for the third new group in which the lobation of the valves is either entirely obsolete, as in *E. indivisa* and *E. umbonata,* or restricted to a simple small median pit or short sulcus, as in *E. umbilicata* and the remaining others of the total of 15 species.

There is no difficulty in drawing the line between *Euklœdenella* and *Klœdenella,* the separation being accomplished on the clearly cut basis of the presence of a well-defined posterior sulcus in the latter and the absence of this sulcus in the former. However, in the case of *Klœdenella* and *Dizygopleura* the separation is not so easily carried out. In defining the limits of these two genera, as intimated above, we are confronted not only with some real and many apparent transitions but also with questions concerning the genetic alliances of certain species that viewed from the empirical standpoint of actual resemblance in character would be referred to *Klœdenella,* whereas the recognition of genetic derivation as a dominant factor in the problem would require their reference to *Dizygopleura.*

A solution of most of these problems has been carefully tested and found to be as a rule readily applied and also to produce the least of confusion and unnaturalness of association. Namely, if the area that normally is affected in the quadrilobation of the valves is clearly outlined on the anterior side and the posterior pair of furrows is well developed then the species falls under *Dizygopleura.* Likewise if the anterior furrow is distinctly developed across at least the ventral half of the valves even when the outer side of the quadrilobate area is not sharply defined. Under the first condition the species *intermedia* and *planata* are admitted to *Dizygopleura* and referred to an extreme position in the group of *D. subdivisa.* Under the second condition the species *proutyi* and its immediate allies and the species *acuminata* together with its closest allies also are referred to *Dizygopleura* and not *Klœdenella.* Just over the line is the species *Klœdenella transitans,* in which the development of the anterior sulcus from the ventral side has progressed only to an insignificant degree and the outer of the two anterior lobes is quite inappreciable. *K. nitida* also has a faint indentation in the ventral slope but makes a truer *Klœdenella* because of the shortness of the posterior sulcus. In *K. cacaponensis,* on the contrary, the posterior sulcus is so long that with the added fact that the anterior side of the lobed area is defined, though rather weakly, it is really doubtful whether this species is more properly placed with *Klœdenella* or in the *D. subdivisa* group of *Dizygopleura.* However, aside from these few mentioned instances wherein valid doubts obtain the classification of the 56 species of American Silurian Klœdenellidæ is reasonably convincing.

Genus *Poloniella* Gurich. In a short paper received while the present work was going through the press Miss J. E. Van Veen[1] asserts the generic identity of *Klœdenella* Ulrich and Bassler and the older term *Poloniella* proposed by Gurich[2] for a rather peculiar ostracod from the middle Devonian ostracod marl of Dombrowa near Kieke, Poland. Gurich based his genus on several whole shells and separated valves of a single species to which he applied the name *Poloniella devonica.* Miss Van Veen reproduces the apparently very good figures originally published by Gurich.

Judging from these illustrations we are regretfully obliged to disagree with the conclusion that our *Klœdenella* viewed either in the broad sense in which it was originally proposed or in the restricted one now given it is identical with Poloniella. On the contrary we doubt that the two belong even to the same family. Unfortunately, we lack the space and time to discuss the relations of these two genera as they should be. Under the circumstances we must content ourselves with the simple statement that in our opinion *Poloniella,* instead of being the same as any of the genera of the Klœdenellidæ is really very near and perhaps generically the same as species now referred to Jones and Holl's genus, *Octonaria.* When the critical revision of the latter genus now in progress shall have been completed it seems not unlikely that *Poloniella* may prove worthy of separate recognition either as a subgenus or independent genus in the family Thlipsuridæ.

Mentioning only the essential differentiating features, the three Silurian genera now recognized as forming the Klœdenellidæ may be briefly characterized as follows:

Euklœdenella, n. gen.: Surface of valves evenly convex or with only a median pit or sulcus and more rarely with a shallow depression in the ventral slope. Genotype, *E. umbilicata* new species.

[1] The identity of the genera *Poloniella* and *Klœdenella,* Koninklijke Akademie van Wettenschappen te Amsterdam, vol. xxiii, 1921.

[2] Gurich, G., Verhandl. der Russisch-Kaiserl. Mineral. Gesellsch. zu St. Petersburg, 2d series, vol. xxxii, 1896.

Klœdenella Ulrich and Bassler (restr.): Surface of valves with a median and a posterior sulcus both usually confined to the post-dorsal quarter, otherwise like *Euklœdenella.* Genotype *K. pennsylvanica* (Jones).

Dizygopleura, n. gen.: Surface of valves usually quadrilobate, rarely trilobate, the lobes separated by three, rarely two, long sulci, of which the anterior may be in part or entirely obsolete. In the former case the anterior sulcus begins on the ventral slope and dies out before reaching two-thirds across the valve; or it may be represented by a crescentic or more rounded depression midway between the dorsal and ventral edges. In the latter case the elevated and anteriorly defined area lying in front of the median sulcus is much wider than the posterior ridges, since it comprises the confluent anterior pair of lobes. Genotype, *D. swartzi* n. sp.

As now known and understood *Klœdenella* is represented by 10 species, *Euklœdenella* by 15 species and 4 named varieties, and *Dizygopleura* by 35 species and 10 partly named varieties. The species of *Euklœdenella* are divisible into five sections or groups. The same number of sections are recognized in classifying the species of *Dizygopleura.* Passing in regular order from the most simple to the most complex type of structure the species of the several genera are named and classified as follows:

Genus EUKLOEDENELLA new genus

	Middle Clinton	Upper Clinton	McKenzie form 50	McKenzie form 100	McKenzie form 50	McKenzie form 50	Wills Creek	Tonoloway Lower	Tonoloway Upper
I. Group of *E. indivisa.* Species without median or other sulci.									
Euklœdenella indivisa n. sp			x						
E. umbonata n. sp			x						
II. Group of *E. umbilicata.* Species with only a median pit or sulcus.									
Euklœdenella umbilicata n. sp			x						
E. umbilicata curta n. var							x		
E. primitioides n. sp			x						
E. primitioides minor n. var			x						
E. brevis n. sp			x						
E. simplex n. sp			x						
III. Group of *E. sinuata.* Species with short median sulcus and projecting antero-ventral flange.									
Euklœdenella sinuata n. sp					x				
E. sinuata angulata n. var					x				
E. sinuata proclivis n. var					x				
E. punctillosa n. sp						x	x		
E. dorsata n. sp					x				
IV. Group of *E. sulcifrons.* Species as in II except that the anterior slope is broadly concave.									
Euklœdenella sulcifrons n. sp			x						
E. similis n. sp			x						
E. abrupta n. sp		x							
V. Group of *E. bulbosa.* Species as in II except anterior third is slightly swollen and segregated by a shallow depression in the ventral slope.									
Euklœdenella bulbosa n. sp			x						
E. foveolata n. sp			x						
E. longula n. sp			x						

Genus KLOEDENELLA Ulrich and Bassler

	Upper Clinton	McKenzie form 50	McKenzie form 100	McKenzie form 50	McKenzie form 50	Wills Creek	Tonoloway Lower	Tonoloway Upper
I. Group of *K. pennsylvanica.* Species with evenly convex surface except the two posterior sulci.								
Klœdenella pennsylvanica (Jones) (Lower Devonian)								
K. obliqua n. sp							x	
K. rectangularis n. sp. (Manlius of New York)								
K. cacaponensis n. sp		x						
K. scapha n. sp		x						
K. scapha brevicula n. var		x	x					
K. subovata n. sp				x				
II. Group of *K. nitida.* Species with a shallow depression in ventral slope.								
Klœdenella nitida n. sp			x					
K. immersa n. sp			x					
K. gibberosa n. sp				x				
K. transitans n. sp		x						

Genus DIZYGOPLEURA new genus

	Middle Clinton	Upper Clinton		McKenzie form				Wills Creek	Tonoloway	
				50	100	50	50		Lower	Upper
I. Group of *D. proutyi.* Anterior sulcus confined to ventral half; anterior lobe more or less bulbous.										
Dizygopleura proutyi n. sp			x							
D. pricei n. sp			x							
D. lacunosa n. sp			x							
D. minima n. sp		x								
D. gibba n. sp						x				
D. carinata n. sp							x			
D. acuminata n. sp							x			
D. acuminata prolapsa n. var							x			
D. affinis n. sp								x		
D. bulbifrons n. sp						x				
II. Group of *D. intermedia.* Anterior side of lobed area defined but anterior sulcus wanting, the pair of anterior lobes confluent.										
Dizygopleura intermedia n. sp				x						
D. intermedia antecedens n. var			x							
D. intermedia cornuta n. var			x							
D. planata n. sp. (Manlius of New York)										
III. Group of *D. subdivisa.* Like II but anterior sulcus developed in anterior median part of raised lobed area.										
Dizygopleura subdivisa n. sp				x						
D. micula n. sp				x						
D. asymmetrica n. sp			x							
D. cranei n. sp			x							
D. loculata n. sp		x								
D. concentrica n. sp						x				
D. subquadrata n. sp				x						
IV. Group of *D. swartzi.* Distinctly quadrilobate, lobes thick, anterior and posterior sulci long, narrow, deeply impressed, the middle sulcus shorter.										
Dizygopleura swartzi n. sp							x			
D. pinguis n. sp				x						
D. falcifera n. sp				x						
D. symmetrica (Hall)			x							
D. stosei n. sp						x				
D. stosei var				x						
D. macra n. sp		x								
Subgroup *D. halli.* Sulci shorter than in typical *D. swartzi.*										
Dizygopleura halli Jones									x	x
D. halli obscura n. var									x	
D. subovalis n. sp										x
D. simulans n. sp									x	
D. simulans limbata n. var									x	
D. clarkei Jones (Manlius of New York)										
V. Group of *D. hieroglyphica.* Valves depressed convex, lobes narrower than the furrows.										
Dizygopleura hieroglyphica (Krause) (Baltic drift)										
D. virginica n. sp. (base of Sneedville ls.)										
D. unipunctata n. sp						x				
D. costata n. sp										x
D. perrugosa n. sp					x					

Genus EUKLOEDENELLA new genus

As mentioned in the foregoing discussion the surface of the valve is evenly convex or with a median pit or sulcus and more rarely with a shallow depression in the ventral slope.

Genotype.—*Euklœdenella umbilicata* new species.

For convenience of description and recognition the known species of *Euklœdenella* may be divided into five groups based upon the surface markings of the valves.

I. Group of *Euklœdenella indivisa*

Species without median or other sulci.

EUKLŒDENELLA INDIVISA n. sp.

Plate LVII, Figs. 1-4

Description.—Length, 1.6 mm.; height, 0.94 mm. Carapace very slightly oblique, the ends being rounded with the greatest convexity in the diagonally opposed corners. Front end somewhat wider, slightly higher and thicker although the slope in profile toward the anterior edge is not very abrupt. Surface smooth, without definite sulci or pit of any sort.

Occurrence.—MCKENZIE FORMATION. Thirty feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA UMBONATA n. sp.

Plate LVII, Figs. 5-7

Description.—Length, 1.75 mm.; height, 1.0 mm. Differs from *E. indivisa* in its very prominent antero-dorsal quarter giving the carapace a somewhat umbonate appearance found in many pelecypods. Besides the vertical edge is straight and there is a slight depression in the middle of the outer slope.

Occurrence.—MCKENZIE FORMATION, 30 feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

II. Group of *Euklœdenella umbilicata*

Species with a median pit or sulcus.

EUKLŒDENELLA UMBILICATA n. sp.

Plate LVII, Figs. 8-12

Description.—Length, usually about 1.5 mm., rarely as much as 1.7 mm. or as little as 1.3 mm.; height, 0.8 mm. The species is characterized by a simple umbilical pit, its oblique round-oblong outline in which there are no sharp curves, and its acuminately elliptical or rather lens-shaped profile in dorsal and ventral views. In such profile views the point of greatest thickness lies nearly always in front of the middle but not far enough to produce any great difference in the slopes to the two ends. In perfect specimens the surface is puncto-reticulate.

Occurrence.—MCKENZIE FORMATION, 30 feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA UMBILICATA var. CURTA n. var.

Plate LVII, Fig. 13

Description.—Length, 1.1 mm.; height, 0.75 mm. In most features like *E. umbilicata* but immediately distinguished by its shorter form. As the shortening is confined to the anterior three-fifths the umbilical pit lies much nearer the midlength than in typical *E. umbilicata.* The anterior also descends much more rapidly.

A general resemblance to *E. simplex* may be noted but the relation to that species is not very close. This is shown (1) in the very different outline of the anterior edge, (2) in the absence of the gentle concavity of the anterior slope pertaining to that species, (3) the absence of a rim on the posterior border and (4) the more uniform convexity of the middle part of the dorso-ventral profile.

Occurrence.—WILLS CREEK FORMATION. Forty-five feet above base, Pinto, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA PRIMITIOIDES n. sp.

Plate LVII, Figs. 14-17

Description.—Length, usually about 0.95 mm., the observed extremes being 0.88 mm., and 1.02 mm. Height, about 0.6 mm.

Allied to *E uklœdenella umbilicata* with which it is associated, but differing in its smaller size and in the overlap of the valves, the right failing to overlap the left anteriorly, the reverse condition obtaining in the genotype. In addition, the carapace is relatively more convex than in *E. umbilicata,* the anterior slope is steeper and the antero-dorsal quarter much thicker. Finally, there is rather more than a suggestion of the sulcus of typical *Klœdenella.*

Occurrence.—MCKENZIE FORMATION. Thirty feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA PRIMITIOIDES var. MINOR n. var.

Plate LVII, Figs. 18-20

Description.—Associated with the typical form of the species are numerous specimens that differ only in being invariably much smaller. So far as observed the length in them ranges between 0.60 mm. and 0.65 mm. In the typical form the length seldom falls under 0.95 mm. The constancy of this small form seems worthy of a varietal name.

Occurrence.—MCKENZIE FORMATION. Thirty feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA BREVIS n. sp.

Plate LVII, Fig. 21

Description.—Length, 1.1 mm.; height, 0.70 mm. Characterized by its relatively short form, nearly regularly oval outline, the dorsal angles being obtuse and the ends subequal. The umbilical pit lies near, just a little anterior to the middle of the dorsal half. Around it are a half-dozen rows of concentrically arranged elongate punctæ. The posterior edge only has a well-developed flat border.

Resembles *E. umbilicata curta* but the middle region of the valves is less convex, the outer more ovate and the pit lies slightly in front instead of behind the middle. The umbilical pit also embraces a larger area.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, 1½ miles east of Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA SIMPLEX n. sp.

Plate LVII, Figs. 22, 23

Description.—Length, 1.8 mm.; height, 1.00 mm. Like *E. sulcifrons* with which it is associated, this species has a broad sloping convexity in the anterior slope but the convexity is not so deep, is less sharply defined on its inner side and the anterior slope on the whole is less steep. Moreover, the anterior part of the outline is more uniformly rounded with the dorsal half less produeed. Finally, the valves are relatively shorter and the umbilieal pit is smaller.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, 1½ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

III. Group of *Euklœdenella sinuata*

Species with short median sulcus and projecting antero-ventral flange.

EUKLŒDENELLA SINUATA n. sp.

Plate LVII, Figs. 24-27

Description.—Length, 1.6 mm.; height, 0.75 mm. Three varieties of this species are recognized. All are marked by a distinctly developed sinus in the ventral edge. The ends are approximately equal in height and in the typical form of the species the outlines of the two ends are similarly incurved at the dorsal angles. In the right valve of the typical variety the dorsal angles are simply rounded or obtusely angular but in the left the posterior extremity of the hinge forms a projecting spinelike process which locks into a corresponding depression in the right valve. The sulcus is rather large and deep but does not extend more than one-third across the valve. Often a barely perceptible depression marks the spot where the posterior sulcus commonly occurs in *Klœdenella.*

The variety *angulata* differs mainly in the more angular antero-cardinal angle and smaller umbilical pit.

The variety *proclivis* also has a smaller umbilical pit but differs from both the typical form and the var. *angulata* in the more sharply angular and more produced antero-dorsal region.

Occurrence.—McKENZIE FORMATION. Seventy-seven and eighty-two feet beneath top, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA SINUATA var. ANGULATA n. var.

Plate LVII, Figs. 28-31; Plate LVIII, Fig. 1

Description.—Associated with the typical form of the species are numerous examples in which the antero-cardinal angle is more angular and the umbilical pit is smaller.

Occurrence.—McKENZIE FORMATION. Seventy-seven and eighty-two feet below top, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA SINUATA var. PROCLIVIS n. var.

Plate LVIII, Figs. 2-5

Description.—Differs from the typical form of the species in its smaller umbilical pit and in the more sharply angular and more produced antero-dorsal region.

Occurrence.—McKENZIE FORMATION. Twenty feet above base at locality 1½ miles east of Great Cacapon, Maryland, Cumberland, Maryland, and upper part of the formation at Flintstone, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA PUNCTILLOSA n. sp.

Plate LVIII, Figs. 7-9

Description.—Length, 1.0 mm.; height, 0.65 mm. *E. punctillosa* is related to *E. sinuata* but the anterior half is relatively much higher and the carapace of inferior size. The umbilical pit also is smaller, the convexity of the valves less and their surface covered with minute crowded punctæ so far not obscured in *E. sinuata* and its varieties.

Occurrence.—MCKENZIE FORMATION. Upper 50 feet at Cumberland, Maryland. A very similar form occurs in the basal 50 feet of the Wills Creek formation at Pinto, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA DORSATA n. sp.

Plate LVIII, Fig. 6

Description.—Length, 1.75 mm.; height, 1.06 mm. Similar to *E. sinuata* and its variety *angulata* in general outline and aspect but differs in various minor details and more importantly in the more shallow and undefined character of the umbilical depression.

Occurrence.—MCKENZIE FORMATION. Eighty-two feet beneath top at Flintstone, Maryland.

Collection.—Maryland Geological Survey.

IV. Group of *Euklœdenella sulcifrons*

Species as in Group II except that the anterior slope is broadly concave.

EUKLŒDENELLA SULCIFRONS n. sp.

Plate LVIII, Figs. 10-12

Description.—Length, 1.6 mm.; height, 0.75 mm. Characterized by its rounded oblong outline, simple small umbilical pit, rather strongly convex valves, and particularly by the wide concavity in the anterior slope.

The greater convexity of the valves, straighter ventral edge and larger size distinguish it from the associated *E. similis*.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, $1\frac{1}{2}$ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA SIMILIS n. sp.

Plate LVIII, Figs. 15, 16

Description.—Length, 0.9 mm.; height, 0.5 mm. Differs from *E. sulcifrons* in the lesser convexity of its valves and the gently convex instead of straight ventral edge. It is also a smaller form and its surface is less prominent in the antero-dorsal quarter.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, $1\frac{1}{2}$ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA ABRUPTA n. sp.

Plate LVIII, Fig. 13

Description.—Length, 0.85 mm.; height, 0.5 mm. This species differs from its allies in the *E. sulcifrons* group in the much greater abruptness of descent and consequent features of the crescentic border. Of other peculiarities we may mention the slight curvature of the inner side of the border and its abrupt termination ventrally. The umbilical pit also is uncommonly shallow and small and seems to be supplemented below by another more rounded pit.

Occurrence.—CLINTON. *Drepanellina clarki* zone at McKees farm, 7 miles west of Lewiston, Pennsylvania.

Collection.—U. S. National Museum.

V. Group of *Euklœdenella bulbosa*

Species as in Group II except anterior third is slightly smaller and segregated by a shallow depression in the ventral slope.

EUKLŒDENELLA BULBOSA n. sp.

Plate LVIII, Fig. 18

Description.—Length, 1.6 mm.; height, 0.9 mm. Related to *E. dorsata* and *E. sinuata* but the antero-ventral projection of the edge—hence also the sinus in middle of ventral edge—is less than in those species. It differs again from both in the development of a low bulbous swelling in the lower middle part of the anterior half. This gives probably a false suggestion of alliance to *Dizyogopleura proutyi*. The umbilical pit is a broad undefined and dorsally flaring depression agreeing in this respect with *E. dorsata*.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, 1½ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA FOVEOLATA n. sp.

Plate LVIII, Fig. 17

Description.—Length, 0.80 mm.; height, 0.50 mm. Related to *E. longula* from which it differs in its much smaller size and relatively higher posterior half. Both have the kind of constriction in front of middle of ventral slope that is so often observed in *Dizygopleura* and *Klœdenella*. This constriction when more fully developed makes the anterior furrow in the deeply sulcated types of the family.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, 1½ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

EUKLŒDENELLA LONGULA n. sp.

Plate LVIII, Fig. 14

Description.—Length, 1.6 mm.; height, 0.75 mm. Related to *E. bulbosa* with which it is associated but is easily distinguished by differences in outline of the ends, in the form of the umbilical pit which is more definitely defined and lower, and in the relatively greater length of the carapace.

Occurrence.—McKENZIE FORMATION. Twenty feet above base, $1\frac{1}{2}$ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

Genus KLOEDENELLA Ulrich and Bassler

Like *Euklœdenella* but surface of valves with a median and a posterior sulcus both usually confined to the post-dorsal quarter.

Genotype.—*Klœdenella pennsylvanica* (Jones).

The 10 species referred at present to this genus may be divided into two groups according to the surface characters of the valves.

I. Group of *Klœdenella pennsylvanica* (Jones)

Species with evenly convex surface except the two posterior sulci.

KLŒDENELLA OBLIQUA n. sp.

Plate LIX, Fig. 1

Description.—Length, 1.3 mm.; height, 0.85 mm. Similar to *K. pennsylvanica* (Jones) but differs in its shorter and more oblique form, more sharply angular anterior cardinal extremity and particularly in the fact that the two posterior furrows are shorter and much nearer the posterior angle. Resembles in general *K. rectangularis* but is a higher form with shorter sulci.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

KLŒDENELLA RECTANGULARIS n. sp.

Plate LIX, Fig. 2

Description.—Length, 1.4 mm.; height, 0.80 mm. *K. rectangularis* has a long sinuous dorsal outline, with sharp rectangular anterior end, deep and long posterior and median sulci extending quite to or beyond the mid-height of valve. There is a well-developed flange on the antero-ventral half. This is practically wanting in the somewhat shorter but similarly oblique right valves of *K. obliqua.* This New York species differs further from that species in the greater length of its two furrows. The posterior furrow is also farther removed from the outer edge and the dorsal edge more sinuous. It seems hardly necessary to compare it with *K. pennsylvanica* though in some respects it is nearer than *K. obliqua.*

Occurrence.—MANLIUS LIMESTONE, Herkimer County, N. Y., in association with *Dizygopleura halli* (Jones), *D. clarkei* (Jones), and *Zygobeyrichia regina* new species.

Collection.—U. S. National Museum.

KLŒDENELLA CACAPONENSIS n. sp.

Plate LIX, Fig. 3

Description.—Length, 1.10 mm.; height, 0.65 mm. The moderately elongate form, obtusely but distinctly angular anterior cardinal angle, long deep posterior furrow, subcarinate posterior pair of lobes, wide and ventrally sharply defined median sulcus, well-developed anterior and postventral border and the very slight definition of the lobed area in the antero-dorsal quarter make a combination of characters that is different from any other species of the family. Some of these features suggest species referred to *Dizygopleura,* as for instance *D. micula* and *D. intermedia,* but the reasons that have caused us to place those species into that genus are too weakly indicated in *K. cacaponensis* to warrant similar action in this instance. The present species agrees too well with *Klœdenella scapha, K. obliqua* and *K. rectangularis* to leave any doubt as to the propriety of placing it in the same genus with them.

Occurrence.—MCKENZIE FORMATION. Twenty feet above base, 1½ miles east of Great Cacapon, Maryland, and other localities exposing this horizon.

Collection.—Maryland Geological Survey.

KLŒDENELLA SCAPHA n. sp.

Plate LIX, Figs. 4-9

Description.—Average length, 1.0 mm.; height, 0.60 mm. Related to *K. transitans* on the one hand and *K. rectangularis* on the other. From the former it differs in its more elongate form, more produced antero-dorsal angle which moreover has a small thickness on the right valve that is characteristic of this and wanting in the other. Further the antero-dorsal quarter of the surface is more convex—fuller—and the point of greatest convexity farther forward than in *K. transitans* in which it is sub-centrally located. Compared with *K. rectangularis* numerous minor and several more important differences will be observed in comparing the illustrations. Among the latter the more curved sulci and the fact that the posterior one lies much nearer this edge of the valve are of particular significance.

A very similar but distinct form with blunter ends as seen in edge views occurs in the Irondequoit limestone of the Upper Clinton near Lockport, New York.

Occurrence.—McKENZIE FORMATION. Thirty feet above base at Flintstone, Maryland and 20 feet above base, $1\frac{1}{2}$ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

KLŒDENELLA SCAPHA var. BREVICULA n. sp.

Plate LIX, Fig. 10

Description.—Length, 1.1 mm.; height, 0.70 mm. This variety is shorter than the typical form of *K. scapha* and differs also in other respects. It also reminds somewhat of *K. obliqua* and *K. rectangularis* on the one hand and in other respects of *K. transitans.* But it is not precisely like any of these and as the general aspect and probably also its affinities seem closest to *K. scapha* it is provisionally referred to this species as var. *brevicula.*

The specimen apparently came from a higher position in the McKenzie formation than that in which the typical form of *K. scapha* is commonly found.

Occurrence.—McKENZIE FORMATION. Ranging from 50 to 150 feet above the base at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

KLŒDENELLA SUBOVATA n. sp.

Plate LIX, Figs. 11-13

Description.—Average length, 1.00 mm.; height, 0.60 mm. We have recognized only right valves of this species and these have an outline that is exceedingly like that of the same valve in *K. gibberosa.* We fear indeed that they belong to that species but judging from the only complete specimen we have seen of *K. gibberosa* this cannot be true because the right side in this species has a peculiar flange in the middle part of the ventral edge that is certainly wanting in these right valves. Instead of a flange the edge in these is undercut. Besides the profiles in the two is different, the point of greatest thickness in that species being near the middle whereas in these the corresponding position is somewhat flat in edge view and the greatest thickness farther forward. For the present then we must regard them as distinct.

Occurrence.—McKENZIE FORMATION, 82 feet beneath top at Flintstone, Maryland.

Collection.—Maryland Geological Survey.

II. Group of *Klœdenella nitida* new species.

Species with a shallow depression in the ventral slope.

KLŒDENELLA NITIDA n. sp.

Plate LIX, Fig. 14

Description.—Length, 1.25 mm.; height, 0.8 mm. About the same size and general aspect as in *K. transitans* but with more convex anterior slope and less defined broader depression in middle of ventral slope. More important differences occur in the furrows which are shorter and less defined; and in the post-median ridge which is more rounded, shorter, less prominent and appears as lying in a sunken area in which the very short posterior sulcus often is difficult to see except in the proper light.

Occurrence.—McKENZIE FORMATION. Middle part at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

KLŒDENELLA IMMERSA n. sp.

Plate LIX, Figs. 15, 16

Description.—Length, 1.25 mm.; height, 0.70 mm. In most of its characters like *K. nitida* with which it was found but it is a longer form, narrow behind with the sunken area around the rounded and low postmedian node more extended in anterior direction and deeper. The middle part of the valves is highly convex, the convexity being accentuated by the depression above and also beneath when the slope is distinctly impressed and the edge sinuate. None of the other species is near enough to require comparison.

Occurrence.—McKENZIE FORMATION. Middle part at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

KLŒDENELLA GIBBEROSA n. sp.

Plate LIX, Figs. 17, 18

Description.—Length, 1.50 mm.; height, 1.00 mm. The main peculiarity of this species is the peculiar crestlike ridge on the middle third of the dorsal margin of the left valve. The right valve is without a similar structure as shown in Fig. 18.

The right valve differs from the left also at the ventral edge, having a kind of flange probably for overlap purposes where the other exhibits only a steep descent.

The two sulci are well developed and deep but do not extend more than two-fifths across either valve.

The anterior sulcus and ridge of *Dizygopleura* are faintly suggested, especially in the larger specimen figured.

Aside from the extraordinary dorsal crest this form is considerably like *K. transitans* and also somewhat less like *K. nitida.* The former even has a crest but of much more modest proportions. Right valves of the two species require most careful discrimination; at that, identifications are not altogether safe except when specimens retain both valves.

Occurrence.—McKENZIE FORMATION. Eighty-two feet below top at Flintstone, and 100 feet below top at Pinto, Maryland.

Collection.—Maryland Geological Survey.

KLŒDENELLA TRANSITANS n. sp.

Plate LIX, Figs. 19, 20

Description.—Length, 1.3 mm.; height, 0.75 mm. The general outline is rounded oblong, the antero-dorsal part only being angular and quite obtusely so. The median and posterior furrows extend about half across the valves, are deep, the former rather wide the latter narrow, and in the left valve both curve strongly forward as they approach the dorsal edge. Just in front of the middle of the ventral edge, which is gently sinuate, there is a faint broad depression that curves forward and upward. The greatest thickness of the carapace lies near the middle of the valves. The right valve overlaps the left posteriorly and ventrally.

This species suggest relations to *Dizygopleura acuminata* at least as great as to *D. turgida* Ulrich and Bassler. It is the anterior sulcus that is more or less imperfectly indicated in these three species and not the outer anterior one. In the species *D. acuminata* and *D. turgida* its development has progressed far enough to leave no doubt as to its meaning. These, therefore, are regarded as belonging to *Dizygopleura* rather than typical *Klœdenella.* The present species on the contrary is still too near in structure to typical *Klœdenella* to warrant placing it in that genus. None of the species of *Klœdenella* (as restricted) is sufficiently close to require detailed comparisons. The main difference used in separating it from *Dizygopleura acuminata* and *D. turgida* has been mentioned already. Others will be observed on comparing the illustrations on the plates.

Occurrence.—McKENZIE FORMATION, 30 feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

Genus DIZYGOPLEURA new genus

Surface of valves usually quadrilobate, rarely trilobate, the lobes separated by three, rarely two, long sulci, of which the anterior may be in part or entirely obsolete.

Genotype.—Dizygopleura swartzi n. sp.

The many species of this prolific genus may be divided into five groups for purposes of comparison.

I. Group of *Dizygopleura proutyi* new species

Anterior sulcus confined to ventral half, anterior lobe more or less bulbous.

DIZYGOPLEURA PROUTYI n. sp.

Plate LIX, Figs. 21-23

Description.—Length, 1.3 mm.; height, 0.9 mm. Related to *D. pricei* and to *D. lacunosa,* in fact these three species form a natural series passing respectively from a short irregularly ovate form to a longer and then a still longer one, and in the progressive development of the depression in the antero-ventral part of the lobed area. In *D. proutyi* this depression extends only about half across the lobed area thus serving to partly separate a small and bulbous rather than ridge-like representation of the anterior lobe from the larger antero-median lobe with which it remains confluent in the antero-dorsal quarter. These convex parts trend diagonally across the valve and are separated from the antero-ventral edge by a wide flange. The posterior sulcus is narrow, nearly closed dorsally, but deep in its lower half. The median sulcus is V-shaped and shorter extending only about two-fifths across the valve. The specific name is in honor of Dr. W. F. Prouty.

Occurrence.—CLINTON. Near top of *Drepanellina clarki* zone at Cumberland and other localities in Maryland and Pennsylvania exposing this horizon.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA PRICEI n. sp.

Plate LIX, Fig. 24

Description.—Length, 1.3 mm.; height, 0.75 mm. Differs from *D. proutyi* with which it is sometimes associated in its greater proportional length more nearly longitudinal trend of the convexities, wider ventral slope but narrower antero-ventral flange. Perhaps more important is the fact that the passage from the anterior to the dorsal part of the outline is without angulation whatever, whereas in *D. proutyi* the antero-dorsal angle is rather prominent.

The specific name is in recognition of the stratigraphic work upon the Silurian of Maryland done by Dr. W. A. Price, Jr.

Occurrence.—CLINTON. *Drepanellina clarki* zone, 21 feet above the Keefer sandstone, Pinto, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA LACUNOSA n. sp.

Plate LIX, Figs. 27-29

Description.—Length, 1.3 mm.; height, 0.7 mm. *D. lacunosa* is more closely allied to *D. pricei* and through it to *D. proutyi* than to any other species known. It is at once distinguished from both of those species by its more elongate carapace. Coming to details the anterior sulcus is longer extending almost to the dorsal edge, near which it attains its greater depth, the median sulcus is deep and more broadly triangular and the posterior sulcus wider and more flat-bottomed than in either of its closest allies.

Occurrence.—CLINTON. *Drepanellina clarki* zone, 17 inches above the Keefer sandstone, 1½ miles east of Great Cacapon, Maryland. Also in the same zone at McKees farm, 7 miles west of Lewiston and at Hollidaysburg, Pennsylvania.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA MINIMA n. sp.

Plate LIX, Fig. 26

Description.—Length, 0.5 mm.; height, 0.3 mm. The exceedingly minute size of this species may of itself suffice in distinguishing it from its structurally nearest allies. None of the specimens so far seen exceed 0.5 mm. in length. *D. gibba,* which is much larger and occurs at a higher horizon, is perhaps as near as any known. The lobation of the valves in the two is similar, especially in the fact that the anterior sulcus is confined to the ventral two-thirds so that the lobes on either side of it merge in the dorsal third. The median and posterior sulci, however, are wider and extend to points nearer the ventral edge than in *D. gibba*. Other species of its group are *D. carinata, D. lacunosa* and *D. proutyi,* all of which are figured in this work.

Occurrence.—CLINTON. *Mastigobolbina typus* zone at Hollidaysburg, Pennsylvania.

Collection.—U. S. National Museum.

DIZYGOPLEURA GIBBA n. sp.

Plate LIX, Fig. 25

Description.—Length, 1.15 mm.; height, 0.7 mm. Allied to *D. halli* but readily distinguished by the much greater fullness of the anterior pair of tubes the hump in middle part of dorsum and the dorsal incompleteness of the anterior sulcus. The ventral part of the anterior sulcus on the contrary is better developed. In most of these respects *D. gibba* is nearer *D. swartzi* particularly to one of its varieties. However, it is clearly distinct also from that species. The dorsal hump in that abundant and variable species is never so strongly developed and the anterior sulcus always extends farther toward the dorsal ridge. Closer allies, most probably are *D. proutyi* and the very much smaller *D. minima*. Both of these occur in the Upper Clinton Lakemont formation. With the aid of our photographic illustrations there seems little excuse for confusion between these three species.

Occurrence.—McKENZIE FORMATION, 82 feet below the top, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA CARINATA n. sp.

Plate LX, Figs. 1-3

Description.—Length, 1.3 mm.; height, 0.8 mm. *D. carinata* seems intermediate in most of its characters between *D. acuminata* and the variety *prolapsa* on the one hand and *D. symmetrica* on the other. It agrees better with the former in the fulness of the ventral part of the anterior lobe but in its outline and lobation it corresponds the more nearly with the second. However, it has several peculiarities of its own so that it is easily distinguished from them all. Compared with the various mutations of *D. symmetrica* it differs strikingly in the carination of the posterior and antero-median lobes, the carina of the latter continuing posteriorly and downward toward the base of the posterior lobe. On further comparison with that species, it is found that the anterior sulcus is straighter and dies out a considerable distance further from the dorsal edge and that the part of the valve in front of it is much wider and being without a ventral flange is also lower.

Occurrence.—McKENZIE FORMATION, upper part at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA ACUMINATA n. sp.

Plate LX, Figs. 4-9

Description.—Length, 1.6 mm.; height, 0.9 mm. Characterized by its produced angular antero-dorsal extremity, outwardly undefined, and rather tumid anterior lobe, ventrally obsolete and narrow posterior sulcus, and dorsally undeveloped anterior sulcus. In the left valve the posterior sulcus is longer than in the right. In a small variety found at Cumberland in the same bed with more typical examples of the species the anterior lobe is less inflated than usual and the anterior sulcus longer and more regularly curved. Except that the anterior sulcus is clearly indicated in the ventral half of the surface the species would have to be referred to *Klœdenella.* None of the other species is very close.

Occurrence.—McKENZIE FORMATION. Very abundant at a zone about 24 feet below the top at Flintstone and Cumberland, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA ACUMINATA var. PROLAPSA n. var.

Plate LX, Figs. 10-12

Description.—Length, 2.1 mm.; height, 1.2 mm. This variety differs from the typical form of the species in being larger, in having more of a medio-dorsal hump especially in the left valve, a less produced antero-dorsal angle and a stronger inflation and downward slumping of the ventral part of the anterior lobe. In some respects it reminds of *D. gibba* but is readily distinguished by its greater size relatively larger anterior lobe and shallower as well as narrower sulci.

Strangely, the specimens of this variety are replaced by marcasite whereas the associated ostracoda have the usual black color.

Occurrence.—MCKENZIE FORMATION. About 24 feet below the top, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA AFFINIS n. sp.

Plate LX, Fig. 13

Description.—Length, 2.1 mm.; height, 1.2 mm. A large species, in fact probably the largest known, the specimens averaging 2.1 mm. in length. Its greatest thickness lies near the middle of the anterior half, hence, in front of the slightly sigmoid anterior sulcus. In general the species reminds of *D. acuminata,* a common and smaller fossil in the upper part of the McKenzie formation. From the typical forms of that species it differs decidedly in the relative obtuseness of the antero-dorsal angle, in the greater width of the anterior and posterior lobes, in the greater fulness of the anterior lobe and in the fact that the anterior sulcus is wider and deeper in the middle part of the valve and does not cross the ventral slope. In fact, this sulcus terminates in this species at a point that would fall about the middle and deepest part of the sulcus in *D. acuminata.*

Closer allies are found among the observed varieties of *D. acuminata.* It agrees with *D. affinis* in the outline of the anterior end but differs in the lesser fulness of the anterior lobe, the much narrower posterior lobe and the greater length of the anterior sulcus. The variety *prolapsa* comes nearer than all in that it too is large and has nearly the same outline with wide anterior and posterior lobes. The only differences of consequence lie in their respective antero-ventral quarters. In *D. acuminata prolapsa* the anterior sulcus is narrow and almost entirely confined to the ventral half, and the greatest fulness of the anterior lobe lies so much lower that the slope to the ventral edge is continuously convex and does not, as in *D. affinis,* pass through a concave space.

Another close ally is *D. bulbifrons,* from the upper part of the McKenzie formation. In that species the sulci, especially the anterior and posterior are deeper and wider and more sharply impressed, the surface of the ridges consequently is somewhat flat and drops abruptly into the sulci, the middle sulcus appears narrower the anterior one extends farther in ventral direction and the ventral edge is almost straight, hence, with much less of a sinus than in *D. affinis.*

Occurrence.—Wills Creek formation. Ninety feet below top, Grasshopper Run, near Hancock, Maryland.

Collection.—Maryland Geological Survey.

Dizygopleura bulbifrons n. sp.

Plate LX, Fig. 14

Description.—Length, 1.9 mm.; height, 1.1 mm. Like *D. stosei* except that the anterior lobe is larger and swollen. It seems also that the sulci are slightly shorter, the anterior failing in dorsal direction and the posterior one in ventral direction. It is probably more closely related to *D. affinis,* a Wills Creek species, but the shallowness or complete absence of a sinus in the ventral part of the outline and its deeper sulci should serve very well in distinguishing them.

Occurrence.—McKenzie formation. Seventy-seven feet below top, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

II. Group of *Dizygopleura intermedia* n. sp.

Anterior side of lobed area defined but anterior sulcus wanting, the pair of anterior lobes confluent.

DIZYGOPLEURA INTERMEDIA n. sp.

Plate LX, Figs. 15, 16

Description.—Length, 1.10 mm.; height, 0.65 mm. The main characteristic of this species is the definite elevation of the anterior side of the area usually lobed in *Dizygopleura* coupled with the fact that the anterior sulcus is entirely wanting. Otherwise it is structurally very close to the more diminutive *D. subdivisa* in which the anterior sulcus is imperfectly indicated.

Occurrence.—MCKENZIE FORMATION. Lower part, Cumberland, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA INTERMEDIA var. ANTECEDENS n. var.

Plate LX, Figs. 18-20

Description.—Length, 1.6 mm.; height, 1.0 mm. This early variety is larger, relatively higher and has a smaller umbilical pit than the typical McKenzie form of the species. Also there is a slight depression within the raised anterior side of the lobed area (incipient anterior furrow) that is not seen in the typical form.

Occurrence.—CLINTON, 17 inches above the Keefer sandstone, 1½ miles east of Great Cacapon, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA INTERMEDIA var. CORNUTA n. var.

Plate LX, Fig. 17

Description.—Length, 1.4 mm.; height, 0.75 mm. Differs from corresponding valves of the typical form in surface contour of antero-ventral quarter where the depressed sloping bordering area is much wider; and particularly in having a blunt spine in front of the middle of the cardinal edge.

Occurrence.—CLINTON. Seventeen inches above Keefer sandstone, 1½ miles east of Great Cacapon, Maryland. IRONDEQUOIT LIMESTONE, 8 miles east of Lockport, New York.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA PLANATA n. sp.

Plate LX, Fig. 21

Description.—Length, 1.50 mm.; height, 0.75 mm. Related to *D. intermedia* and with it forms a small extreme section of the group of *D. subdivisa* and at the same time of *Dizygopleura* differing from the more typical species of the genus in the entire absence of the anterior furrow. From its immediate allies it differs in the transverse flatness of the lobate area, in the sigmoid anterior outline and sharpness of the latter, in the greater width of the posterior lobe, longer more sharply defined and more nearly vertical posterior and median furrows, and in the anteriorly curving prolongation of the dorsal extremity of the posterior lobe.

Occurrence.—MANLIUS LIMESTONE, Herkimer County, N. Y. This species may be expected in the Tonoloway limestone of Maryland.

Collection.—U. S. National Museum.

III. Group of *Dizygopleura subdivisa* n. sp.

Like II but anterior sulcus developed in anterior median part of raised lobed area.

DIZYGOPLEURA SUBDIVISA n. sp.

Plate LXI, Figs. 1, 2

Description.—Length, 0.55 mm.; height, 0.35 mm. This small species is an outgrowth of *Dizygopleura asymmetrica* from which it differs in being smaller, less convex, with shallower sulci and more angularly produced antero-dorsal region. Both this and the following species trend toward typical *Klœdenella* but the development of the anterior pair of sulci has gone too far or is still too well expressed to keep them out of *Dizygopleura*. At the same time their evident relationships to *Dizygopleura intermedia* and *D. planata* lend confidence to their position under *Dizygopleura*.

Occurrence.—MCKENZIE FORMATION. Thirty feet above base, Flintstone, Maryland, and at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA MICULA n. sp.

Plate LXI, Fig. 3

Description.—Length, 0.65 mm.; height, 0.35 mm. A small species quite similar to *D. subdivisa* but differing in its greater length and less distinct development of the sulci.

Occurrence.—MCKENZIE FORMATION. Thirty feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA ASYMMETRICA n. sp.

Plate LXI, Figs. 9, 10

Description.—Right valve: Length, 1.30 mm.; height, 0.80 mm. This species has a wide inclined flange on anterior (left) side with unthickened edge. On the right valve the anterior flange appears wider and has a thickened border that overlaps the left valve. The right valve therefore is more elongate than the left. The species is related to *D. symmetrica* and more particularly to *D. subdivisa.* From the former it will be distinguished at once by its shorter posterior sulcus and the altogether different lobing of the anterior half; from the latter by its more rounded and less oblique anterior outline and the dorsal incurving of the anterior lobe. Close comparisons bring out differences in many other respects.

Occurrence.—CLINTON. *Drepanellina clarki* zone, Cumberland Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA CRANEI n. sp.

Plate LXI, Figs. 4-8

Description.—Length, 1.0 mm.; height, 0.60 mm. Four right valves showing some variation in the height of the anterior end and in the development of the low and thin ridge that often defines the ventral side of the lobed part of the valves are figured. In 5 and 6 this marginal ridge is practically wanting and the swelling of the antero-ventral half also is greater than in 7 and 8 in which the ridge occurs. This difference in convexity is perhaps more apparent than a real increase in thickness. The anterior sulcus is represented by a small elongate crescentic depression on which account the species is referred to the group of *D. subdivisa.* In its group it stands distinctly apart from the others with *D. intermedia* and *D. subdivisa* probably its nearest relatives. In *D. intermedia,* however, the anterior sulcus is entirely obsolete and the anterior end higher and made by a wide sloping area that is much wider than in *D. cranei.* In *D. subdivisa* the valves are relatively shorter, the whole surface less convex and the anterior sulcus narrower and longer but much shallower. In both of the McKenzie species the posterior sulcus is narrower and the lobes on either side of it are thicker.

Occurrence.—CLINTON, *Drepanellina clarki* zone. McKees farm, 7 miles west of Lewiston, Pennsylvania.

Collection.—U. S. National Museum.

DIZYGOPLEURA LOCULATA n. sp.

Plate LXI, Figs. 13, 14

Description.—Length, 1.20 mm.; height, 0.65 mm. Allied to *D. symmetrica* and *D. asymmetrica* but readily distinguished from both, and in fact all other species of the genus by the dorso-ventral restriction of the antero-median sulcus so as to form a simple rounded pit. Whereas the posterior half of the valves is much the same as in the mentioned species the anterior half looks quite different.

Occurrence.—CLINTON, *Mastigobolbina typus* zone. Lakemont, Hollidaysburg, Pennsylvania. Near Great Cacapon, West Virginia, and various Maryland localities exposing this zone.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA CONCENTRICA n. sp.

Plate LXI, Fig. 11

Description.—Length, 0.90 mm.; height, 0.60 mm. Related to *D. subdivisa* having a very similar outline and also mostly shallow sulci.

However, this is a slightly larger form and more convex in the median part of the valves. More important differences are: (1) the fact that the two median lobes form a horseshoe shaped loop that is divided below from the ventral continuation of the anterior ridge by a shallow furrow; (2) the ventral continuation of the anterior ridge which does not occur in that species but in this overhangs the contact margin and terminates at the base of the posterior part of the outline; (3) the post-median lobe more of a ridge than a rounded boss; and, finally, (4) the two posterior sulci are deeper.

Occurrence.—McKENZIE FORMATION. One hundred feet below top, Pinto, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA CONCENTRICA var. SUBQUADRATA n. var.

Plate LXI, Fig. 12

Description.—Length 0.60 mm.; height, 0.40 mm. In this minute early variety of *D. concentrica* the two median lobes are united below to form a squarish loop defined on the ventral side by an uncommonly deep furrow or transversely elongated pit. The posterior and antero-median sulci which bound the loop laterally are deep in their dorsal two-thirds but shallow ventrally. The anterior ridge curves backward around the ventral edge which it overhangs in the middle and thence passes into the posterior ridge. In typical *D. concentrica* confluence of the ventral and posterior ridges can hardly be said to occur. The depression in the middle of the ventral slope also is not so deep whereas the passage between it and the antero-median sulcus is much more gradual in the typical form than in this variety. Should these differences prove constant the two would deserve to be held as distinct species. Provisionally it will suffice to distinguish them as varieties. The smaller form does not suggest immaturity.

Occurrence.—McKENZIE FORMATION. Thirty feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

IV. Group of *Dizygopleura swartzi* n. sp.

Distinctly quadrilobate, lobes thick, anterior and posterior sulci long, narrow, deeply impressed, the middle sulcus shorter.

DIZYGOPLEURA SWARTZI n. sp.

Plate LXII, Figs. 1-8

Description.—Typical form. Length, 1.00 mm.; height, 0.65 mm. Greatest thickness just in front of the mid-length. Otherwise the species is considerably like the younger (Manlius) *D. clarkei* and *D. halli.* However, in both of them the posterior as well as the anterior lobe is thicker and the anterior sulcus does not extend so far downward as in *D. swartzi.* In the latter again the anterior sulcus commonly is not so deep nor so wide in its middle part as in the two Manlius species. But the difference mainly relied is the fact that the two median lobes are more prominent than either of the lateral ones, whereas in *D. halli* and *D. clarkei* the four lobes attain practically the same plane.

Besides the typical form, which is represented by Plate LXII, Figs. 1, 2, four varieties or mutations have been observed. One is characterized by an uncommonly wide and differently outlined frontal slope.

The second (both probably from upper 50 feet of McKenzie) is more elongate than the others except var. 1 and has a deeper and wider inwardly sloping anterior sulcus.

The third is distinguished by relatively high posterior end, the anterior part being distinctly the narrower. It is peculiar also in lacking the sinus in the median part of ventral outline.

The fourth, which is abundant at Flintstone, 24 feet beneath top of McKenzie, differs from the other mutations in its relative shortness and the clear definition and greater depth of the lateral sulci.

Occurrence.—MCKENZIE FORMATION. Upper third at Cumberland, Flintstone, Pinto, etc., Maryland, where it almost completely fills certain thin layers of limestone.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA PINGUIS n. sp.

Plate LXII, Figs. 9, 10

Description.—Length, 1.00 mm.; height, 0.62 mm. Size and general outline not much different from that of *D. symmetrica* and *D. concentrica* but differing in various respects from both. Obesity of the carapace and its narrow sulci distinguishes it particularly from the former. The variety *subquadrata* of *D. concentrica* is more like *D. pinguis* than is the typical form of that species. However, *D. pinguis* is without the deep impression in the ventral slope that characterizes the variety *subquadrata.*

Occurrence.—McKENZIE FORMATION, 30 feet above base, Flintstone, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA FALCIFERA n. sp.

Plate LXII, Figs. 11, 12

Description.—Length, 1.1 mm.; height, 0.55 mm. Related most closely to *D. stosei,* especially to its small older variety, and to *D. concentrica subquadrata* but quite obviously represents a distinct species distinguished mainly by its produced antero-dorsal angle and certain peculiarities in the ventral parts of the ribs. Namely, the anterior ridge is decidedly recurved in its dorsal part and the furrow behind it is deep and rather wide, in both of which features it differs from *D. subquadrata.* Nor does *D. falcifera* show anything like the ventral depression of that species, but it does show a very slender raised line in that position. Anteriorly this line passes into the outer edge of the anterior lobe. From *D. stosei,* which probably is its nearest relative, this present species differs in its smaller size and conspicuously different form.

Occurrence.—McKENZIE FORMATION, 20 feet above base, $1\frac{1}{2}$ miles east of Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA SYMMETRICA (Hall)

Plate LXII, Figs. 13-17

Beyrichia symmetrica Hall, 1852, Pal. New York, vol. ii, p. 317, pl. lxvii, fig. 16.

Bollia symmetrica Ulrich and Bassler, 1908, Proc. U. S. Nat. Mus., vol. xxxv, p. 319, fig. 61.

Description.—Length, 1.10 mm.; height, 0.70 mm. In 1908 we left this species under *Bollia,* to which it had previously been referred by the senior author. Study of the original types together with an abundance of specimens recently collected at Lockport, N. Y., has shown conclusively that the species is not a *Bollia* but a true member of the Klœdenellidæ and one of the strongly lobate and quite typical species of *Dizygopleura.* Its characters are sufficiently brought out in the illustration to make a description unnecessary.

Occurrence.—ROCHESTER SHALE, Lockport, etc., New York. CLINTON, *Drepanellina clarki* and *Mastigobolbina typus* zones at localities in Maryland and Pennsylvania, particularly at Cumberland, Md.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA STOSEI n. sp.

Plate LXII, Figs. 18-20

Description.—Length, 1.4 mm.; height, 1.0 mm. *D. stosei* is of the type of *D. symmetrica* but differs: (1) in having the tops of the ridges flattened and sharp-edged instead of rounded; (2) in the greater length of the median sulcus; and (3) in having a short, dorsally directed spine at the anterior cardinal angle; and (4) in being considerably larger. The general aspect of the two species is sufficiently different because of the greater rigidity of the lobes in *D. stosei,* so that with the other peculiarities mentioned there seems little danger of confusion. The specific name is in honor of Mr. George W. Stose, of the U. S. Geological Survey.

Occurrence.—MCKENZIE FORMATION, 62 feet below top, Flintstone, Md., and 20 feet above Keefer sandstone, 1½ miles east of Great Cacapon, Md.

Collection.—U. S. National Museum.

DIZYGOPLEURA MACRA n. sp.

Plate LXII, Figs. 21-23

Description.—Length, 0.80 mm.; height, 0.45 mm. This species seems to be related on the one hand to *D. symmetrica* and its allies and *D. virginica* and *D. perrugosa* on the other. From the former it is distinguished by its thin ridges—on especially the ventral part of the loop, which is very thick in that species—and its broad furrows, which together with the delicacy of the ridges impart an emaciated appearance that is scarcely suggested in that species. The valves are also much longer relatively. Compared with *D. virginica* the outline is found to differ and the triangular thickening at the base of the loop which characterizes the species of the *D. hieroglyphica* group is wanting. *D. perrugosa* is a much larger and more rugged species.

Occurrence.—CLINTON, *Mastigobolbina typus* zone, near Six Mile House, Md.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA HALLI (Jones)

Plate LXII, Figs. 24, 25

Beyrichia halli Jones, 1890, Quart. Jour. Geol. Soc. London, vol. xlvi, p. 15, pl. iv, fig. 21.

Klœdenella halli Ulrich and Bassler, 1908, Proc. U. S. Nat. Mus., vol. xxxv, p. 319, fig. 62, pl. xliii, fig. 4.

Description.—Right valve, length, 1.10 mm.; height, 0.70 mm. Characterized by its moderately elongate form, angular dorsal extremities, sinuate ventral edge, deep furrows which extend nearly to the dorsal edge but become obsolete before reaching the middle of the ventral half. It is commonly associated with *D. clarkei,* which it resembles sufficiently to require some care in discriminating them. However, *D. clarkei* is a larger and relatively shorter form, with broadly rounded instead of angular postero-dorsal region and different furrows. The anterior one is shorter in that species, especially in its dorsal extent, whereas the posterior one is longer in ventral direction. Further, the anterior sulcus is farther removed from the anterior edge, so that the outer of the pair of anterior lobes is wider and the inner one is relatively narrower than in *D. halli.* Finally, the right valve has a wide, deeply concave border around the anterior and more than half of the ventral side, the like of which does not occur in the present species.

Occurrence.—Lower (typical) MANLIUS of New York. TONOLOWAY LIMESTONE, Grasshopper Run, near Hancock, Pinto and other Maryland localities.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA HALLI var. OBSCURA n. var.

Plate LXII, Fig. 26

Description.—Length, 1.3 mm.; height, 0.75 mm. A relative or distinct variety of *Dizygopleura halli* in which the sulci tend toward obsolescence, being shorter, narrower, and shallower. The anterior pair especially is much weaker than the typical form of the species. This divergence from type brings typical *Klœdenella* to mind, but we are fully convinced that the true affinities of the variety are with *D. halli* on the one hand and *D. swartzi* and *D. symmetrica* on the other, hence, that it is genetically a species of *Dizygopleura.* As shown in the figure, specimens of the variety are exceedingly abundant on certain bedding planes.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, Keyser, W. Va., Pinto and other Maryland localities.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA SUBOVALIS n. sp.

Plate LXII, Fig. 27

Description.—Right valve. Length, 1.10 mm.; height, 0.70 mm. In its lobation *Dizygopleura subovalis* is intermediate between *D. halli* and *D. clarkei* but differs from both in its rather definitely oval outline. The difference in this respect is particularly notable on the ventral side, which is distinctly convex instead of more or less concave in the middle.

Occurrence.—TONOLOWAY LIMESTONE. Numerous zones at Keyser, W. Va., Pinto and other Maryland localities.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA SIMULANS n. sp.

Plate LXII, Fig. 28

Description.—Right valve. Length, 1.00 mm.; height, 0.70 mm. Like *Dizygopleura subovalis* but is shorter and too narrow in anterior half. Resembles also *D. clarkei* but lacks the wide hollow anterior border of that species. The anterior lobe also is smaller and the anterior sulcus extends farther up toward dorsum. The ventral outline also is gently convex instead of slightly sinuate in the middle.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, Keyser, W. Va., Pinto and other localities in Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA SIMULANS var. LIMBATA n. var.

Plate LXII, Figs. 29, 30

Description.—Length, 0.85 mm.; height, 0.55 mm. Distinguished by its shorter form and anterior sulcus, but particularly by its wide and continuous border. The continuity of the border around the ventral edge is a very unusual feature in species of this genus.

Occurrence.—TONOLOWAY LIMESTONE. Lower part, Keyser, W. Va., Pinto, etc., Md.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA CLARKEI (Jones)

Plate LXII, Figs. 31, 32

Beyrichia clarkei Jones, 1890, Jour. Geol. Soc. London, vol. xlvi, p. 17, fig. 2.

Description.—Length, 1.30 mm.; height, 0.90 mm. In this right valve, which is the original type of the species, the anterior sulcus seems to extend as a definite depression farther in dorsal direction than in the better example of same valve in the U. S. National Museum that also is figured on this plate. Otherwise, however, the two are practically identical in character. The surface pitting and apparent tuberculation probably is due to unequal corrosion of the test. The same cause may be at least partly responsible for the lengthening of the anterior sulcus. *Dizygopleura clarkei* has much in common with *D. swartzi* out of which it may have been derived.

Occurrence.—Lower (typical) MANLIUS of Schoharie County, New York. Associated with *Dizygopleura halli* (Jones), *Zygobeyrichia regina* new species, etc. Will probably be found in the Tonoloway limestone of Maryland.

Collection.—U. S. National Museum.

V. Group of *Dizygopleura hieroglyphica* (Krause)

Valves depressed convex, lobes narrower than the furrows.

DIZYGOPLEURA VIRGINICA n. sp.

Plate LX, Figs. 27-29

Description.—Length, 1.00 mm.; height, 0.58 mm. Evidently related to *D. hieroglyphica* (Krause) (see Plate LX, Fig. 22) common species in the Silurian drift in the Baltic region of Germany. The Virginia specimens differ in having thinner ridges and correspondingly wider furrows and in lacking the two pits in the triangular ventral thickening of the loop.

These species are strikingly like certain Ordovician and Richmond species now referred to *Tetradella* (*e. g., T. quadrilirata*). Possibly the suggested relationship is closer than has been believed hitherto.

Occurrence.—SNEEDVILLE LIMESTONE, Big Stone Gap, Virginia, in shale just over the basal conglomerate associated with *D. bulbifrons* and Upper McKenzie species.

Collection.—U. S. National Museum.

DIZYGOPLEURA UNIPUNCTATA n. sp.

Plate LX, Fig. 25

Description.—Length, 1.30 mm.; height, 0.75 mm. This species, though probably more closely related to *D. hieroglyphica* (Krause) than to any other now described, is clearly differentiated by its large size, relatively longer valves, sinuate ventral edge, the single instead of two depressions in the thick ventral part of the loop and more carinate ridges. Other minor differences are to be noted in detailed comparison of the ridges and furrows. For instance, the posterior ridge is narrow and the post median one much more so.

Occurrence.—McKENZIE FORMATION. Seventy-seven feet below top at Flintstone, Maryland.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA COSTATA n. sp.

Plate LX, Figs. 23, 24

Description.—Length, 0.95 mm.; height, 0.60 mm. This species also is not far removed from *D. hieroglyphica* (Krause) and at least belongs to the same section of the genus. Specifically, however, it is readily distinguished not only from the Baltic species but also the various members of the same group found in the Appalachian region by its more quadrate outline, and also by the fact that the depressions at the base of the loop open below instead of forming pits. Finally, the species is marked by the peculiar fact that the ridge summits are grooved.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, W. Va., Pinto, etc., Md.

Collection.—Maryland Geological Survey.

DIZYGOPLEURA PERRUGOSA n. sp.

Plate LX, Fig. 26

Description.—Length, 1.6 mm.; height, 0.80 mm. This species differs from all others in shape and general aspect. It is marked in particular by extraordinary high ridges, carinate at their summits and correspondingly deep and wide sulci which extend completely across the valves. The two ridges that form the inner loop are especially prominent and peculiarly joined at their dorsal and ventral extremities. On the dorsal side of the left valve this loop projects well over the edge and when the valves are in position it overlaps the edge of the right valve and locks on its anterior side with a smaller projecting process of the right valve.

Occurrence.—MCKENZIE FORMATION. Middle part at Cumberland, Maryland.

Collection.—Maryland Geological Survey.

Superfamily CYPRIDACEA

Family THLIPSURIDAE

Genus OCTONARIA Jones

OCTONARIA CRANEI n. sp.

Plate LXIII, Fig. 12

Description.—Length, 0.70 mm.; height, 0.40 mm. This interesting early Silurian species is not, as might be expected, related to the Silurian genotype *O. octoformis* Jones but to the Devonian *O. stigmata* Ulrich, which has oblong instead of rounded valves. Indeed, *O. cranei* is the earliest known of the *O. stigmata* group.

The species is so different from all other Silurian Ostracoda that no difficulty will be encountered in its identification. The specific name is in honor of Mr. W. E. Crane, who collected the type specimen.

Occurrence.—CLINTON. *Drepanellina clarki* zone at McKees farm, 7 miles west of Lewiston, Pa.

Collection.—U. S. National Museum.

OCTONARIA MURICATA n. sp.

Plate LXIII, Figs. 10, 11

Description.—Length, 1.25 mm.; height, 0.90 mm. Somewhat similar in surface characters to *Octonaria angulata* Ulrich and Bassler from the lowest Devonian (Keyser) rocks of Maryland but differing conspicuously in its more equal ended instead of sharply angular valves. The pit is a well-marked feature in all of the specimens so far worked. The lobing of the valves is so different from any other Maryland Silurian Ostracoda that comparisons are unnecessary.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, W. Va.

Collection.—Maryland Geological Survey.

Family CYPRIDAE

Genus BYTHOCYPRIS Brady

BYTHOCYPRIS PHASEOLUS Jones

Plate LXIII, Figs. 5, 6

Bythocypris phaseolus Jones, 1887, Ann. and Mag. Nat. Hist. (5), vol. xix, p. 189, pl. vii, figs. 11, 12.

Description.—Length, 0.80 mm.; height, 0.50 mm. Specimens of a *Bythocypris* occurring abundantly on the surface of thin bedded limestones in the Upper Tonoloway limestone are so similar to *B. phaseolus* Jones described from the Wenlock of England that we have little hesitancy in identifying them as above.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, W. Va.

Collection.—Maryland Geological Survey.

BYTHOCYPRIS PHILLIPSIANA Jones and Holl

Plate LXIII, Fig. 9

Bairdia phillipsiana Jones and Hall, 1869, Ann. and Mag. Nat. Hist. (4), vol. iii, p. 213, pl. xiv, figs. 7a-c.

Description.—Length, 0.90 mm.; height, 0.55 mm. The Maryland specimens referred to this European Silurian species vary slightly from the published illustrations but hardly enough to make the determination doubtful under present methods of discrimination.

Occurrence.—MCKENZIE FORMATION. Eighty-two feet below top at Flintstone, Md.

Collection.—Maryland Geological Survey.

BYTHOCYPRIS OBESA Jones

Plate LXIII, Fig. 8

Bythocypris symmetrica obesa Jones, 1889, Ann. and Mag. Nat. Hist. (6), vol. iv, p. 270, pl. xv, fig. 7.

Description.—Length, 1.00 mm.; height, 0.50 mm. Originally described from the Silurian of the Island of Gotland, this species marked by its unequal, rounded ends and tumid carapace appears to be represented in the McKenzie formation of Maryland.

Occurrence.—MCKENZIE FORMATION. Cumberland, Md.

Collection.—Maryland Geological Survey.

BYTHOCYPRIS PHASEOLINA n. sp.

Plate LXIII, Fig. 7

Description.—Length, 1.00 mm.; height, 0.45 mm. Although somewhat similar in outline to *Bythocypris phaseolus* Jones this species may readily be distinguished by its more elongate carapace with more equal ends. Ostracoda very similar in outline have been figured by Jones and by Krause under the name of *Bythocypris symmetrica* Jones, but these are undoubtedly not typical *B. symmetrica* as figured by Jones.

Occurrence.—TONOLOWAY LIMESTONE. Lower part at Keyser, W. Va.

Collection.—Maryland Geological Survey.

BYTHOCYPRIS ? KEYSERENSIS n. sp.

Plate LXIII, Figs. 1, 2

Description.—Length, 0.80 mm.; height, 0.35 mm. Distinguished from other Silurian species of *Bythocypris* by its somewhat quadrate elliptical outline and by the rather straight dorsal and ventral edges. Better preserved material is necessary before the true alliances of this species can be determined.

Occurrence.—TONOLOWAY LIMESTONE. Upper part at Keyser, W. Va.

Collection.—Maryland Geological Survey.

BYTHOCYPRIS PERGRACILIS n. sp.

Plate LXIII, Figs. 3, 4

Description.—Length, 1.30 mm.; height, 0.55 mm. The elongate slender carapace of this ostracod is so different from other Silurian species that the shape alone will suffice to distinguish it. Added to this the fact that the left valve is larger and overlaps the right and that the surface is smooth makes a combination of characters quite distinctive for the species.

Occurrence.—McKENZIE FORMATION, 20 feet above base, $1\frac{1}{2}$ miles east of Great Cacapon, W. Va. Equally elongate specimens from the WILLS CREEK FORMATION, 45 feet above the base at Pinto, Md., are referred to the species.

Collection.—Maryland Geological Survey.

Subclass TRILOBITA

Order OPISTHOPARIA

Family PROETIDAE

Genus PROETUS Steininger

PROETUS (?) sp.

Plate XXXIII, Fig. 8

Description.—Pleura of pygidium grooved, causing them to appear double towards axis, single anteriorly. Margin flat, narrow. Surface finely granulose. The fragment here described does not appear to be clearly referable to any described species. It is too imperfect to permit specific identification.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain.

Collection.—Maryland Geological Survey.

Family LICHADIDAE

Genus CORYDOCEPHALUS Hawle and Corda

CORYDOCEPHALUS PTYONURUS (Hall and Clarke)

Plate XXXIII, Fig. 7

Lichas (Dicranogmus) ptyonurus Hall and Clarke, 1888, Pal. N. Y., vol. vii, p. 86, pl. xixB, figs. 19-21.

Corydocephalus ptyonurus Bassler, 1915, U. S. Nat. Mus., Bull. 92, vol. i, p. 281.

Description.—" Pygidium relatively large, flabellate, depressed convex. Axis less than one-third as wide as the shield upon the anterior margin, strongly arched upon the first two annulations, becoming depressed posteriorly, tapering to an obtuse termination just below the center of the pygidium and connected with the posterior margin with an elevated ridge. it bears three distinct annulations and seven transverse rows of postules and the posterior-lateral area is covered with scattered tubercles and granules."—Hall, 1888.

The description of the pygidium of the New York species applies exactly to the specimens from Maryland. Hall and Clarke's figures, however, do not clearly show the ridge which extends posteriorly from the axis of the pygidium to the border. A comparison of the Maryland forms with the type specimen shows the two to be identical. This species occurs also in the Cobleskill of Schoharie County, New York.

Length of pygidium, 8.6 mm.; width, 10 mm.

Occurrence.—MCKENZIE FORMATION. Grasshopper Run, West Virginia, 35 feet below the top of the formation.

Collection.—Maryland Geological Survey.

Order PROPARIA

Family ENCRINURIDAE

Genus ENCRINURUS Emmrich

ENCRINURUS ORNATUS Hall and Whitfield

Plate XXXIII, Figs. 9, 10

Cybele punctata Hall, 1852, Pal. N. Y., vol. ii, p. 297, pl. Alxvi, figs. 1a-b.
Encrinurus punctatus Billings, 1860, Cat. Sil. Foss. Anticosti, Geol. Survey Canada, p. 61 (loc. ref.).
Encrinurus ornatus Hall and Whitfield, 1875, Pal. Ohio, vol. ii, p. 154, pl. vii, fig. 16.
Cryptonymus ornatus Vogdes, 1878, Mon. Gen. Lethus, Cybelle, etc., p. 23.
Encrinurus ornatus Chamberlin, 1883, Geol. Wisc., vol. i, p. 195, fig.
Encrinurus ornatus Foerste, 1887, Bull. Denison Univ., vol. ii, p. 102.
Encrinurus punctatus Foerste, 1890, Proc. Boston Soc. Nat. Hist., vol. xxiv, p. 269.
Encrinurus punctatus Norton, 1896, Proc. Iowa Acad. Sci., vol. iii, p. 79.
Encrinurus punctatus Foerste, 1897, Bull. Sci. Lab. Denison Univ., vol. ii, p. 103.
Encrinurus punctatus Van Ingen, 1901, School of Mines Quart., p. 66, pl. p. 27.
Encrinurus ornatus Grabau, 1901, Bull. N. Y. State Mus., No. 45, p. 225, fig. 157.

Encrinurus ornatus Grabau, 1901, Bull. Buffalo Soc. Nat. Hist., vol. vii, p. 225, fig. 157.

Encrinurus ornatus Grabau and Shimer, 1910, N. A. Index Fos., vol. ii, p. 314, fig. 1627.

Description.—"Buckler semicircular or subcrescentiform, the posterior angles extended into long spines, glabella clavate, not lobed; surface of glabella and cheeks tuberculous, body composed of 11 articulations; caudal shield with seven to nine articulations in the lateral lobes, and 21 in the middle lobe. Every fourth or fifth articulation of the middle lobe tuberculated; oculiform tubercles prominent."—Hall, 1852.

In the Maryland specimens the mesial tubercles are found on the second, fifth, ninth, and thirteenth segments. There are eight lateral articulations.

The Maryland individuals seem to be slightly closer to the European forms than to those of New York, having, like the former, but one row of tubercles on the lateral articulations.

This species is represented by one caudal shield which is beautifully preserved, and by several free cheeks showing the tuberculations.

Length of the pygidium observed, 5 mm.; breadth, 5 mm.

Occurrence.—ROCHESTER FORMATION. Rose Hill, east of Tonoloway, Maryland; Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

Family CALYMENIDAE

Genus LIOCALYMENE Raymond

LIOCALYMENE CLINTONI (Vanuxem)

Plate XXXIV, Figs. 1-4

Hemicrypturus clintoni Vanuxem, 1842, Geol. Rept. N. Y., Rept. 3d Dist., p. 79, fig. 2.

Hemicrypturus sp. Hall. 1843, Geol. N. Y., pt. 4, p. 77, tab. org. rem., 9, fig. 2.

Calymmene clintoni Hall, 1852, Pal. N. Y., vol. ii, p. 298, pl. Alxvi, figs. 5a-d.

Calymmene blumenbachii var. *senaria* Hall, 1852, Pal. N. Y., vol. ii, p. 299, pl. Alxvi, figs. 6a-e.

Calymmene clintoni Rogers, 1858, Geol. Survey Penn., vol. ii, p. 823, fig. 637.

Calymmene clintoni Vodges, 1880, Proc. Acad. Nat. Sci., Phila., p. 178, fig. 4. not fig. 3.

Calymmene clintoni Lesley, 1889, Geol. Survey Penn., Rept. P4, p. 109, figs.

Calymmene clintoni Foerste, 1909, Cincinnati Soc. Nat. Hist. Jour., vol. xxi, p. 33, pl. i, fig. 6.

Description.—"Buckler short, sublunate, width three or four times the length; glabella four-lobed, narrower in front, the posterior lobe larger than either of the others, and the anterior one scarcely larger than the adjoining ones; body broad above, middle lobe gradually diminishing toward the caudal shield; lateral lobes of nearly the same width as the middle lobe; caudal shield trilobate, the middle lobe with eight or nine articulations, the lateral one smooth; surface granulate."—Hall, 1852.

This species is found throughout the Maryland area and ranges from below the lower ferruginous sandstone of the Kirkland formation to the base of the Keefer sandstone.

Length, 22 mm.; width, 12 mm. A second individual is 28 mm. wide

Occurrence.—ROCHESTER FORMATION. Cumberland, Flintstone, Maryland; Great Cacapon, West Virginia. ROSE HILL FORMATION. Throughout the Maryland area.

Collection.—Maryland Geological Survey.

Genus CALYMENE Brongniart

CALYMENE NIAGARENSIS Hall [1]

Plate XXXIII, Figs. 11-14

Calymmene niagarensis Hall, 1843, Geol. N. Y., Sur. 4th Geol. Dist., p. 101. fig. 3, and p. 102.

Calymmene blumenbachii var. *niagarensis*, Hall, 1852, Pal. N. Y., vol. ii, p. 307, pl. lxvii, figs. 11, 12.

Calymmene niagarensis Hall, 1870, 20th Rept. N. Y. State Geol. Cab. Nat. Hist., p. 400; rev. edit., p. 425.

Calymmene niagarensis Hall, 1879, 28th Rept. N. Y. State Mus. Nat. Hist., Mus. ed., p. 187, pl. xxxii, figs. 8-15.

Description.—General form ovate. Head semicircular or sublunate. Glabella marked by three tubercles on either side, the lower pair being much more prominent than the others. Thorax gradually tapering from

[1] For full synonymy of this species see Bassler, U. S. Nat. Mus., Bull. 92. 1915, vol. i, p. 168.

the base of the head, composed of 13 articulations, those of the middle lobe being bent abruptly upwards at their extremities, with a distinct longitudinal groove reaching nearly their whole length, or to the arching of the ribs. Pygidium with about eight articulations in the middle lobe, and five in each lateral lobe, those of the lateral lobes grooved nearly to the margin, which is thickened and reflexed. Surface granulose.

Glabella, 12 mm. long; pygidium, 11 mm. long and 18 mm. wide.

Occurrence.—ROCHESTER FORMATION. Flintstone, east of Tonoloway, Maryland; Great Cacapon, West Virginia. ROSE HILL FORMATION. Hanging Rock, northwest of Clear Spring, Maryland.

Collection.—Maryland Geological Survey.

CALYMENE NIAGARENSIS var. RESTRICTA Prouty n. var.

Plate XXXIV, Figs. 5-9

Description.—This form differs from *C. niagarensis* in having the front of the glabella slightly more truncate, and the grooves separating the lateral articulations of the pygidium usually slightly more restricted. The larger pygidia of this form are practically indistinguishable from those of *Calymmene blumenbachii* var. *macrocephala.* This variety occurs abundantly in a zone 35 feet to 45 feet below the top of the McKenzie.

Average length of glabella 14 mm.

Occurrence.—MCKENZIE FORMATION. Flintstone, Maryland; Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

CALYMENE MACROCEPHALA Prouty n. sp.

Plate XXXIV, Figs. 10-13, 18

Description.—Cephalon of larger individuals 1 inch in length; glabella bearing three lateral pairs of lobes, the posterior pair subtriangular and well defined, the middle pair more nearly circular and about one-half the diameter of the posterior pair, the anterior pair always small, sometimes indistinct and having the appearance of an elliptical or circular tubercle. Glabella well defined by a deep lateral groove which becomes very narrow at the second pair of lobes, but which broadens anteriorly and separates the glabella from the raised anterior border, which is a little broader than the groove. The anterior groove and raised anterior border occupy fully one-fourth of the total length of the cephalon. Palpebral lobes are slightly anterior to the middle lobes of the glabella; fixed cheeks strongly elevated; facial sutures about parallel along the fixed cheeks, anterior to the eyes, then curving slightly outward to the anterior border. The postero-lateral margins are extended, their width considerably exceeding the greatest width of the glabella at the posterior pair of lobes. Pygidium having a semicircular outline anteriorly, moderately curved posteriorly, becoming nearly straight behind the mesial lobe; mesial lobe tapering posteriorly, its sides forming an angle of about 27°, having six distinct segments and a wedge-shaped terminal piece which bears the suggestion of a seventh narrow segment on its anterior border. Each lateral lobe bears four strongly curved segments which bifurcate at a point situated one-third to one-half their length from the outer margin. The last segment bifurcates sometimes, though it is usually simple. It runs directly to the posterior margin and is nearly parallel to the groove between the lateral and mesial lobes. This species is very closely allied to the English forms *C. blumenbachii* var. *auctorum* from the Woolhope or Lower Wenlock of Bogmine, Shropshire, and to *C. blumenbachii* var. *caractaci* from the Caradoc rocks of Shropshire. From the variety *auctorum* it differs essentially in the slightly more acute angle of the glabella, the wider anterior groove and margin, and the more extended marginal and fixed cheek; from the variety *caractaci* it differs in the greater breadth of its anterior margin and groove and the more extended lateral fixed cheek. It differs also from both the above in the character of its facial suture. The species *macrocephala* is perhaps more closely allied to an American form *C. vodgesi* Foerste, which is cited from the "Clinton" of Ohio and of Georgia, than it is to the English species. A careful study of the description and drawing of *C. vodgesi* warrants its separation from the Maryland forms. While the species from Ohio has the wide anterior margin, it lacks the more extended lateral margins, and its anterior pair of lobes are more prominent and angular than in the

Maryland species. It is possible that a more extended comparison of individuals from Maryland and Ohio may show them to be identical. The pygidia of the English and American forms would hardly serve as a means of separation.

A cephalic shield measures 16 mm. long, 15.5 mm. wide. A larger shield is 25 mm. long. Two pygidia measure 17 mm. long, 32 mm. wide, and 14 mm. long, 30 mm. wide, respectively.

Occurrence.—McKENZIE FORMATION. Grasshopper Run, West Virginia. A pygidium probably of this species was found 35 feet below the top of formation. ROCHESTER FORMATION. Cumberland, Flintstone, a pygidium probably of this species. ROSE HILL FORMATION. One-half mile north of Cresaptown, abundant in a disintegrated yellow sandstone a few feet below the ferruginous sandstone, associated with *C. cresapensis*, Cumberland, Hanging Rock, northwest of Clear Spring.

Collection.—Maryland Geological Survey.

CALYMENE CRESAPENSIS Prouty n. sp.

Plate XXXIV Figs. 14-17

Description.—Glabella almost as broad as long, two-thirds as wide in front as at posterior lateral lobe, bearing three well marked lateral lobes, the first one small and angular, the other two successively larger and more rounded or globular; frontal lobe of glabella small but considerably broader than the second lateral lobe; fixed cheeks closely approach the glabella, but are separated from it by a deep narrow groove; front broader and groove narrow; postero-lateral margins of head shield about equal in lateral extent to the widest part of the glabella; middle lobe of pygidium bearing six or seven articulations, lateral lobe with four pleuræ, posterior border broadly rounded, sometimes slightly concave.

The head of this species resembles somewhat closely that of *C. clintoni*, while the pygidium resembles very closely that of *C. macrocephala*. The fixed portion of the head shield and the pygidium are found in abundance, associated with *C. macrocephala*. The cephalic shield differs from that of the latter variety chiefly in having a prominent second lobe and in the closer approach of the fixed cheek to the front portion of the glabella.

This species is always small, the glabella being 10 mm. long in large specimens.

Occurrence.—ROSE HILL FORMATION. Pinto, one-half mile north of Cresaptown, abundant, just below the lower Clinton ore, with *C. macrocephala,* Cumberland, Six-mile House, Maryland; Sir Johns Run, West Virginia; Keefer Mountain, Pennsylvania.

Collection.—Maryland Geological Survey.

CALYMENE CAMERATA Conrad

Plate XXXV, Figs. 1-3

Calymmene camerata Conrad, 1842, Jour. Acad. Nat. Sci., Phila., vol. viii, p. 278.

Calymmene camerata Hall, 1852, Pal. N. Y., vol. ii, p. 337, pl. lxxviii, figs. 1a-f.

Calymmene camerata Weller, 1903, Geol. Survey N. J., Pal. vol. iii, p. 250, pl. xxii, figs. 22-25.

Calymmene camerata Maynard, 1913, Md. Geol. Survey, Lower Dev., p. 494, pl. lxxxix, fig. 9.

Description.—" Cephalic shield wide, subcrescent form; anterior margin elevated in a strong fold, a deep groove separating it from the front of the glabella and cheeks; glabella broader and nearly straight in front, furnished on each side with three distinct tubercles, the posterior one very large and prominent, the anterior one minute; eyes opposite to the central lobe of the glabella; the furrow between the glabella and cheeks very deep; a projecting lobe from behind the eye touches or unites with the middle of the three lobes of the glabella, and a similar projecting plate from the inner anterior angle of the cheek touches the front lobe of the glabella near its anterior angle. Axis of the body convex, nearly as wide as the lateral lobes; pleuræ convex and straight for half their length, and then gently curved downwards and flattened, grooved along the center. Caudal shield with eight rings in the middle lobe; lateral lobes with six flat ribs strongly bent downwards; surface granulate, with larger tubercles on the glabella and other parts.

" The specimens examined are all imperfect, and the surface markings are also more or less obliterated. The characteristic features are the deep furrow along the front and cheek margins, and between the glabella and cheeks, and the projecting lobes from the inner margins of the cheeks which touch or unite with the glabella, arching over the axial furrow. In the two separated cephalic shields, the portion beyond the facial suture is wanting, and in the more entire specimen it is too obscure to be characterized."—Hall, 1852.

This species is characterized by a lobe which projects from behind the eye and unites with the middle lobe of the glabella. In other respects it is very near *C. blumenbachii.*

Glabella: Length, 15 mm.; width, 12 mm. Pygidium: Length, 6 mm.; width, 11 mm.

Occurrence.—TONOLOWAY FORMATION. Quarry of Standard Lime and Stone Company, Keyser, West Virginia. WILLS CREEK FORMATION. Flintstone Creek, Round Top, Maryland; Log Road south of Grasshopper Run, West Virginia.

Collection.—Maryland Geological Survey.

Genus HOMALONOTUS Koenig

HOMALONOTUS DELPHINOCEPHALUS (Green)

Plate XXXV, Figs. 5-10

Trimerus delphinocephalus Green, 1832, Mon., p. 82, pl. i, fig. 1; Monthly Amer. Jour. Geol., vol. i, p. 560.

Trimerus delphinocephalus Harlan, 1835, Trans. Geol. Soc. Penn., vol. i, p. 105.

Brongniartia platycephala Eaton, 1832, Geol. Text-book, p. 32, pl. ii, fig. 20.

Brongniartia platycephala Green, 1832, Mon. Tril. N. Amer., p. 91.

Ogygia latissima Silliman, 1832, Amer. Jour. Sci., vol. xx, p. 136.

Homalonotus delphinocephalus Murchison, 1839, Sil. System, p. 651, pl. vii bis, fig. 1a, b.

Homalonotus ahrendi Roemer, 1843, Verst. des Herzgebirges, p. 39, pl. xi, fig. 5.

Homalonotus delphinocephalus Hall, 1843, Geol. Rept. 4th Dist. N. Y., p. 103.

Homalonotus delphinocephalus De Verneuil, 1847, Note sur le parallelisme, etc., p. 47.

Homalonotus delphinocephalus Hall, 1852, Pal. N. Y., vol. ii, p. 309, pl. lxviii, figs. 1-14.

Homalonotus delphinocephalus Salter, 1865, Mon. Brit. Tril. p. 113, pl. xi, figs. 1-10.

Homalonotus delphinocephalus Hall, 1879, 28th Ann. Rept. N. Y. State Mus. Nat. Hist., pl. xxxii, figs. 17, 18.

Homalonotus delphinocephalus Hall, 1882, 11th Ann. Rept. Dept. Geol. Nat. Hist. Ind., p. 332, pl. xxxiv, figs. 17, 18.

Homalonotus delphinocephalus Grabau, 1901, Bull. Buffalo, Soc. Nat. Sci., vol. vii, p. 221, fig. 153.

Homalonotus delphinocephalus Foerste, 1909, Jour. Cincinnati Soc. Nat. Hist., vol. xxi, No. 1, p. 34, pl. ii, figs. 19a, b, c.

Homalonotus delphinocephalus Grabau and Shimer, 1910, N. Amer. Index Fos., vol. ii, p. 317, fig. 1630.

Description.—"Head ovate or subtriangular, arcuate at the base, more or less convex in the middle and compressed in front, often subacute at the extremity; glabella scarcely defined; margin around the front often elevated; posterior margin of buckler marked by a strong continuous ridge or pseudo-articulation; facial suture in front, parallel and coincident with, or slightly within, the flexure of the margin, passing thence obliquely through the eye, and turning, comes to the margin a little above the posterior angle; articulations of the body, 13; central lobe or axis broad, scarcely defined, the articulations continuous, with a slight bend along the line of separation; articulations with a broad deep groove or furrow running near to the anterior margin, and continuing across the axis and into the lateral lobes to the point where they bend downwards, below which it is a sharp, impressed line; lateral articulations falciform, flattened, much expanded and rounded at the extremities, anterior margin arcuate; caudal shield triangular, acute and acuminate at the extremity; middle lobe with 11 to 13 articulations, lateral lobes with seven to nine articulations; surface populose-granulate or scabrous."—Hall, 1852.

In all the Maryland forms observed the glabella is slightly broader than long and narrower in front than posteriorly. Two specimens from the shale have practically smooth glabella and their palpebral lobes are but slightly elevated, thus resembling the figured forms from New York (vol. ii, Pal. N. Y., 1859), save that the latter have a more quadrate glabella.

Cephalon: Length, 17 mm.; width, 25 mm. Pygidium: Length, 25 mm.; width, 25 mm. Some individuals attain a much greater size.

Occurrence.—ROCHESTER FORMATION. Throughout the Maryland area. ROSE HILL FORMATION. Cumberland ?

Collection.—Maryland Geological Survey.

HOMALONOTUS LOBATUS Prouty n. sp.

Plate XXXV, Figs. 11-16

Description.—Cephalic shield semicircular in outline, the larger forms observed being about 11 mm. in length and about three-fifths as long as broad; fixed cheeks bluntly rounded not extending posteriorly; palpebral lobes elevated and situated well to the front; slope from eye to border short; anterior border narrow; glabella moderately convex with a tendency toward an elevation along the median line from which the surface of the glabella flattens laterally. All the divisions of the glabella are accentuated to a greater degree than is usual in this genus, suggesting a close relationship with the genus *Calymmene.* While the glabella is distinctly lobed, the anterior pair of lobes is scarcely discernible on the upper surface of the carapace; all the lateral grooves of the glabella are shallow, while the median and posterior pair of lobes lack the usual bulbous form of those of the genus *Calymmene.* Occurring with the cephalic shields are numerous pygidia which are indistinguishable from those of *H. delphinocephalus* and which apparently belong to this species.

Length of cephalic shield in a large form, 11 mm.; width, 18.5 mm.

Occurrence.—ROCHESTER FORMATION. Throughout the Maryland area.

Collection.—Maryland Geological Survey.

Family PHACOPIDAE

Genus DALMANITES Emmrich

DALMANITES LIMULURUS (Green) [1]

Plate XXXV, Figs. 17-21

Asaphus limulurus Green, 1832, Mon. Tril. N. Amer., p. 48, cast 16.
Asaphus limulurus Green, 1832, Monthly Amer. Jour. Geol., vol. i, p. 559.
Phacops limulurus Hall, 1852, Pal. N. Y., vol. ii, p. 303, pl. lxvii, figs. 1-8.
Dalmanites limulurus Grabau and Shimer, 1910, N. Amer. Index Fos., vol. ii, p. 325, fig. 1641.

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[1] For the extended synonymy of this species see Bassler U. S. Nat. Mus., Bull. 92, 1915, vol. i, pp. 384, 385.

Description.—"Buckler sublunate, with the spines at the posterior angle extended; front extended in a short obtusely angular point; glabella lobed; anterior lobe broad, separated from the three smaller lobes on each side by a broad oblique furrow, which communicates with the longitudinal furrow separating the cheeks from the glabella; lower lobes separated by sharp transverse grooves, the lower lobe continuing across the center in a slightly defined ridge; eyes of medium size, the base opposite the two upper of the three small lobes of the glabella; facial suture extending to the margin of the shield, on a line with or a little above the base of the eyes; body with 11 articulations, axis broadest in the middle, the articulations with thickened obtuse terminations, but not tuberculate; articulations of the later lobes deeply grooved from the base more than two-thirds of their length, and having the extremities bent rather abruptly downwards; caudal shield with the central lobe consisting of 15 articulations, which terminate in an elevated obtuse point below; lateral lobes with eight articulations, all except the upper one grooved throughout their whole length till they are merged into a thickened border; this thickened border, extending along the two sides of the pygidium, is united below the termination of the central lobe, and extended into a long spine-like process; entire surface granulated."—Hall, 1852.

A species of Dalmanites which has fewer pygidial segments is found in the upper Rose Hill. Ulrich proposes elsewhere in this volume to call this *D. clintonensis.*

Two individuals measure, respectively, as follows: Length of glabella, 10 mm.; width of cephalic shield, 21 mm.; and length of glabella, 12.5 mm.; width of cephalic shield, 26 mm.

Occurrence.—ROCHESTER FORMATION. Throughout the Maryland area. ROSE HILL FORMATION. Flintstone, Maryland, Great Cacapon, West Virginia.

Collection.—Maryland Geological Survey.

CLASS ARACHNIDA
Subclass MEROSTOMATA
Order EURYPTERIDA
Family EURYPTERIDAE
Genus EURYPTERUS Dekay

EURYPTERUS FLINTSTONENSIS Swartz n. sp.

Plate LXVI, Fig. 1

Description.—Carapace semielliptical in outline, closely resembling that of *Dolichopterus cumberlandicus,* but much smaller. Eyes situated about midway between the center and lateral margins and in front of center of head. The first tergite, which is the only part of the abdomen preserved in specimen described, is a narrow band, its posterior margin concave, its post-lateral angles rounded. This species is represented by a single individual.

Width of carapace, 18 mm.; length, 12 mm.; eyes, 4 mm. in greater diameter.

Occurrence.—TONOLOWAY FORMATION. National Road on Martin Mountain in a small quarry at turn of road.

Collection.—Maryland Geological Survey.

Genus HUGHMILLERIA Sarle

HUGHMILLERIA sp. cf. SHAWANGUNK Clarke and Ruedemann

Plate LXVI, Fig. 2

Hughmilleria shawangunk Clarke, 1907, N. Y. State Mus. Bull. No. 107, p. 308, pl. iv, figs. 1-4; pl. v, figs. 1-9.

Hughmilleria shawangunk Grabau and Shimer, 1910, N. A. Index Fos., vol. ii, p. 413, fig. 1714.

Hughmilleria shawangunk Clarke and Ruedemann, 1912, N. Y. State Mus., Mem. No. 14, p. 342, pls. lxiv-lxvi; pl. lxix, fig. 1.

Description.—Carapace semielliptical, width slightly greater than length. Sides but slightly curved, converging anteriorly, curving rapidly near anterior end of eye into anterior margin, which is very convex but not quite semicircular, and surrounded by a narrow band. Posterior margin concave. Surface convex. Compound eyes semilunar; their length one-fourth the length of the carapace, width about one-third length; situated so that a line drawn back of their posterior ends passes nearly through the center of the carapace, their distance from the margin being about equal to their width in the single specimen observed. Ocellar mound not seen.

A single specimen of the carapace of this species, which is probably somewhat distorted by pressure, has been observed. It closely resembles some of the immature forms of *H. shawangunk.*

Carapace: Width, 13 mm.; length, 12 mm.

Occurrence.—Wills Creek Formation. Cement quarries on Wills Creek, Cumberland.

Collection.—Maryland Academy of Science.

Genus DOLICHOPTERUS Hall

Dolichopterus cumberlandicus Swartz n. sp.

Plate LXVI, Figs. 3, 4; Plate LXVII, Figs. 1-3

Description.—Carapace semielliptical in outline, length three-fourths width; its posterior margin concave, forming an acute angle with lateral margins; lateral margins nearly straight, converging anteriorly, curving and joining anterior margin near eye; anterior margin moderately arcuate, not fully preserved; surface of carapace convex.

Eyes large, situated near lateral margins; semilunar, placed obliquely, their length about one-fifth width of carapace, very convex, protruding exteriorly, joining carapace interiorly by a flattened surface. The walking legs bear prominent spines; swimming legs not well known. Abdomen tapering slowly anteriorly, becoming rapidly constricted at from third to fourth segments. Preabdominal sternites having rounded postlateral angles; postlateral angles of postabdominal sternites acute, produced into short lappets; length of sternites increasing rapidly posteriorly to fourth. Last sternite longer than wide and nearly twice as long as the fifth sternite; narrower in front, its lateral margins curving outwards back of middle of segment and produced at postlateral angles in long lappets between which the telson is inserted. Telson long, narrow, ensiform, carinate on ventral side.

Width of carapace, 45 mm.; length, 34 mm.; eyes, 9 mm. long; width of abdomen, 55 mm. Length of individual must have approximated 225 mm.

This fine species is represented by a number of parts of individuals. The description is based upon separate head and abdomen and thus represents a composite individual. The material is, however, associated in the same bed and appears to belong to one species. The species is found in the uppermost beds of the Wills Creek.

Occurrence.—WILLS CREEK FORMATION. Cedar Cliff, West Virginia.

Collection.—Maryland Geological Survey.

Genus PTERYGOTUS Agassiz

PTERYGOTUS (?) sp.

Plate LXVII, Figs. 4-6

Description.—A few fragments of eurypterids, found by Mr. G. S. Stose, were submitted to Clarke and Ruedemann, who reported concerning them as follows: "The material contains some recognizable parts of the integument; two carapaces, some tergites, small patches with ornamentation, and a telson. All these, save the carapaces, have the characteristics of a *Pterygotus,* especially in the sculpture, which consists of large, semicircular, posteriorly rising scales, and the telson. The smaller of the two carapaces is either a distorted *Dolichopterus,* comparable to *D. otisius,* or a *Pterygotus,* approaching a *Slimonia* in outline. The larger is too incomplete for determination; what there is of it also points to the *Hughmilleria-Pterygotus* group. There is also a small fragment that suggests a badly crumpled carapace of *Hughmilleria.*"—Clarke and Ruedemann, 1912.[1]

Occurrence.—ROCHESTER FORMATION. Black shale interbedded in the Keefer sandstone member, near Lock 53, 3 to 4 miles above Hancock.

Collection.—U. S. Geological Survey.

[1] *Pterygotus* sp. or *Dolichopterus* sp. Clarke and Ruedemann, 1912, N. Y. State Mus., Mem. 14, p. 88, pl. lxx, figs. 6-8.

PLATES

PLATE IX

PAGE

FIG. 1. BUTHOTREPHIS GRACILIS Hall var. INTERMEDIA Hall.............. 395
Showing cluster of branching stems.
McKenzie formation, Flintstone Creek, Md.

FIGS. 2-8. FAVOSITES NIAGARENSIS Hall................................ 396
2. Section perpendicular to tubes, × 3.
3. Section parallel to tubes, × 3.
4. Same, showing mural pores, × 3.
McKenzie formation, Rose Hill, Md.
5. Section parallel to tubes.
6. Same, × 5.
7. Section perpendicular to tubes.
8. Same, × 5.
Tonoloway formation, Keyser-Heddenville Road, Keyser, W. Va.

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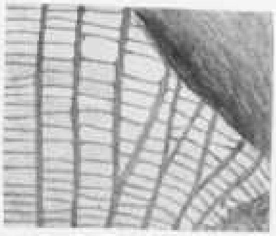

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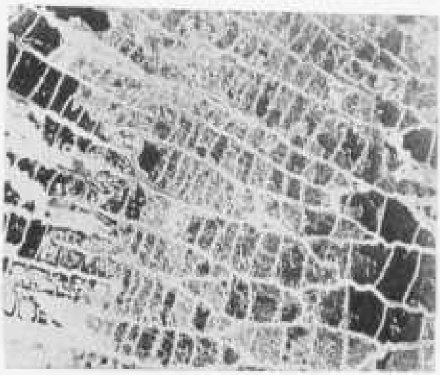

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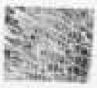

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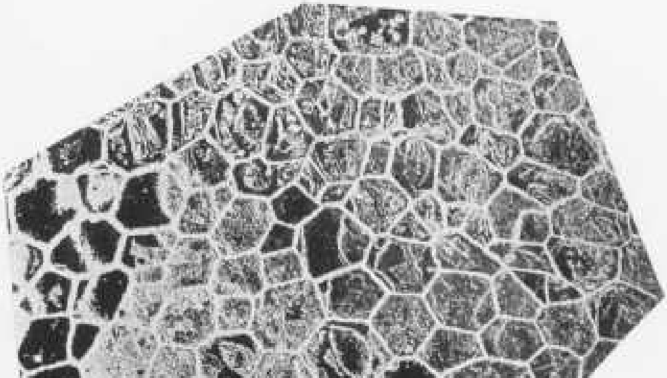


8

CŒLENTERATA-ANTHOZOA.

PLATE X

PAGE

FIGS. 1-3. FAVOSITES sp. 398

1. Internal cast of corallum seen from above.
2. Internal cast of corallum seen from below.
3. Internal cast of a single corallite, × 8.

Rochester formation, Six-Mile House, Md.

FIGS. 4, 5. FAVOSITES MARYLANDICUS Prouty........................ 397

4. View of a corallum showing its dendroid form.
5. Section perpendicular to corallites, × 3½.

McKenzie formation, Cedar Cliff, Md.

FIGS. 6, 7. AULOPORA TONOLOWAYENSIS Swartz........................ 398

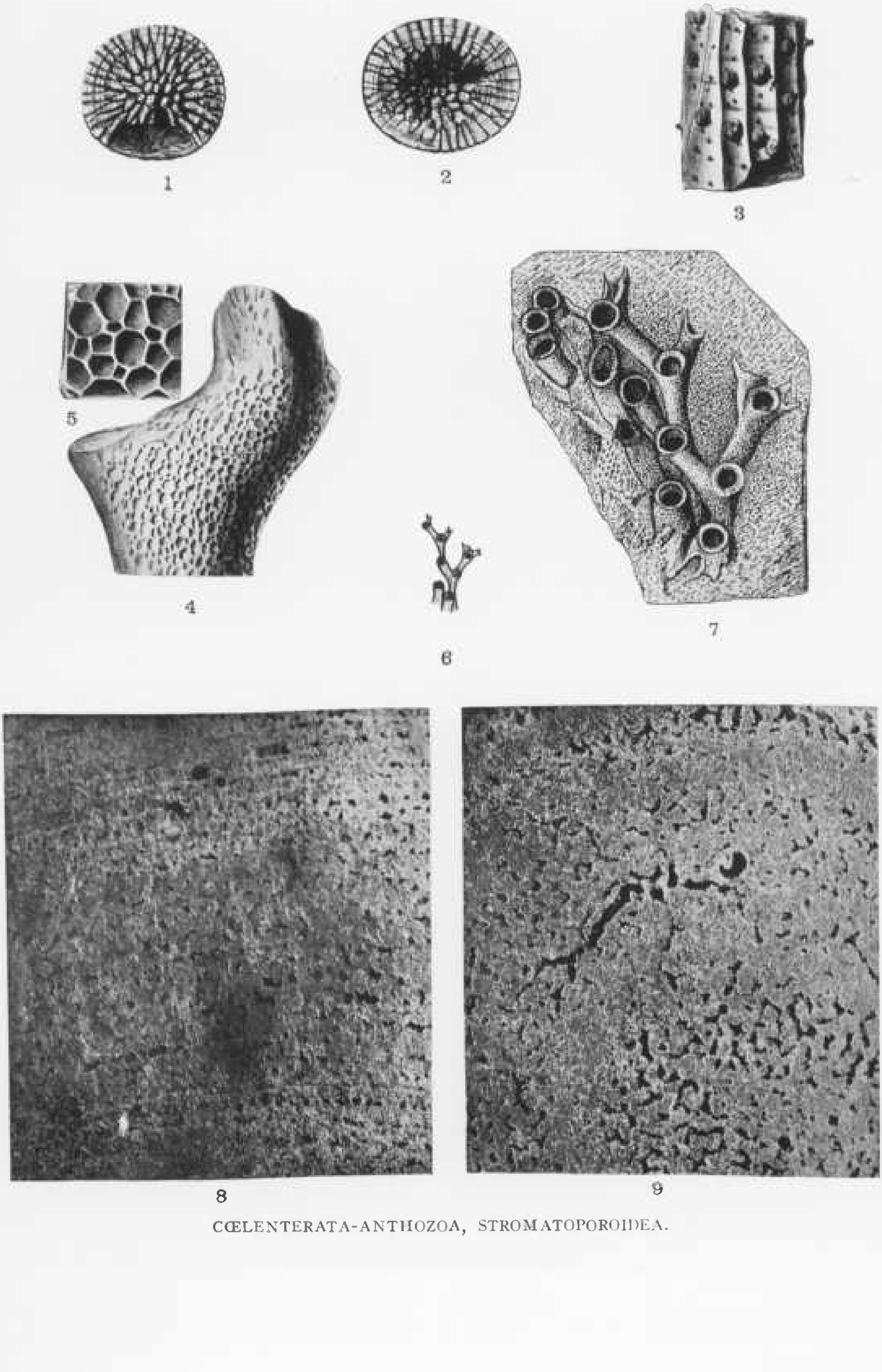
6. Nat. size.
7. Same, × 3.

Tonoloway formation, Keyser-Heddenville Road, Keyser, W. Va.

FIGS. 8, 9. STROMATOPORA CONSTELLATA Hall........................ 399

8. Radial section, × 10.
9. Tangential section, × 10.

Tonoloway formation, Keyser-Heddenville Road, Keyser, W. Va.



CŒLENTERATA-ANTHOZOA, STROMATOPOROIDEA.

PLATE XI

PAGE

FIGS. 1-4. CORNULITES CONCAVUS Prouty.............................. 402

1. Shell showing surface sculpture.
2. Internal cast.
3. Small internal cast, × 2.
4. Fragment of shell showing details of ornamentation, × 4.

Rochester formation, Rose Hill, Md.

FIG. 5. CORNULITES ROSEHILLENSIS Prouty............................ 402

Internal cast.

Rochester formation, Rose Hill, Md.

FIGS. 6, 7. CORNULITES CANCELLATUS Prouty.......................... 403

6. Fragment, × 4.
7. Portion of same showing surface sculpture, × 20.

Rochester formation, Great Cacapon, W. Va.

FIG. 8. SCOLITHUS VERTICALIS Hall.................................. 403

Burrows of this species.

Medina formation, Monroe Co., N. Y.

FIG. 9. CRINOID STEM ....Not described in text

Rochester formation, Flintstone Creek, Specimen loose from near top of Keefer sandstone.

VERMES.

PLATE XII

1. Sandstone covered by the stems of this species, × ⅓.

   Medina formation, Gorge below Niagara Falls, N. Y. (This is the form named *F. brogniarti* by Harlan.)

2. Cluster of branching stems, × ⅓. (This is the form named *F. alleghaniensis* by Harlan.)

   Tuscarora formation, "The Narrows," Cumberland, Md.

2

1

ARTHROPHYCUS.

PLATE XIII

PAGE

FIGS. 1-3. CHASMATOPORA ASPERATOSTRIATA (Hall).....Not described in text

1. Noncelluliferous side of a zoarium, natural size.
2. Enlargement of same showing the asperate striate character.
3. Celluliferous surface of zoarium, enlarged (Figs. 1-3 after Hall).

Rochester shale, Lockport, N. Y.

FIG. 4. RHOPALONARIA TENERRIMA n. sp. 405

Type consisting of delicate, pinnately arranged impressions in the substance of a shell, × 9.

McKenzie formation, lower part, Pinto, Md.

FIGS. 5-9. CYPHOTRYPA EXPANDA n. sp. 407

5. Basal side of portion of a zoarium, showing the strongly wrinkled epitheca, × 1½.
6. Celluliferous side, exhibiting the polygonal, thin walled, normal zooecia inconspicuous acanthopores and absence of mesopores. A group of larger zooecia is shown in the upper right hand corner, × 20.
7. Tangential thin section, showing the simple zooecial structure, × 20.
8. Zooecia of the same section, with the small acanthopores and the clear interzooecial space more visible, × 35.
9. Vertical thin section, through a single layer of zooecia, × 20.

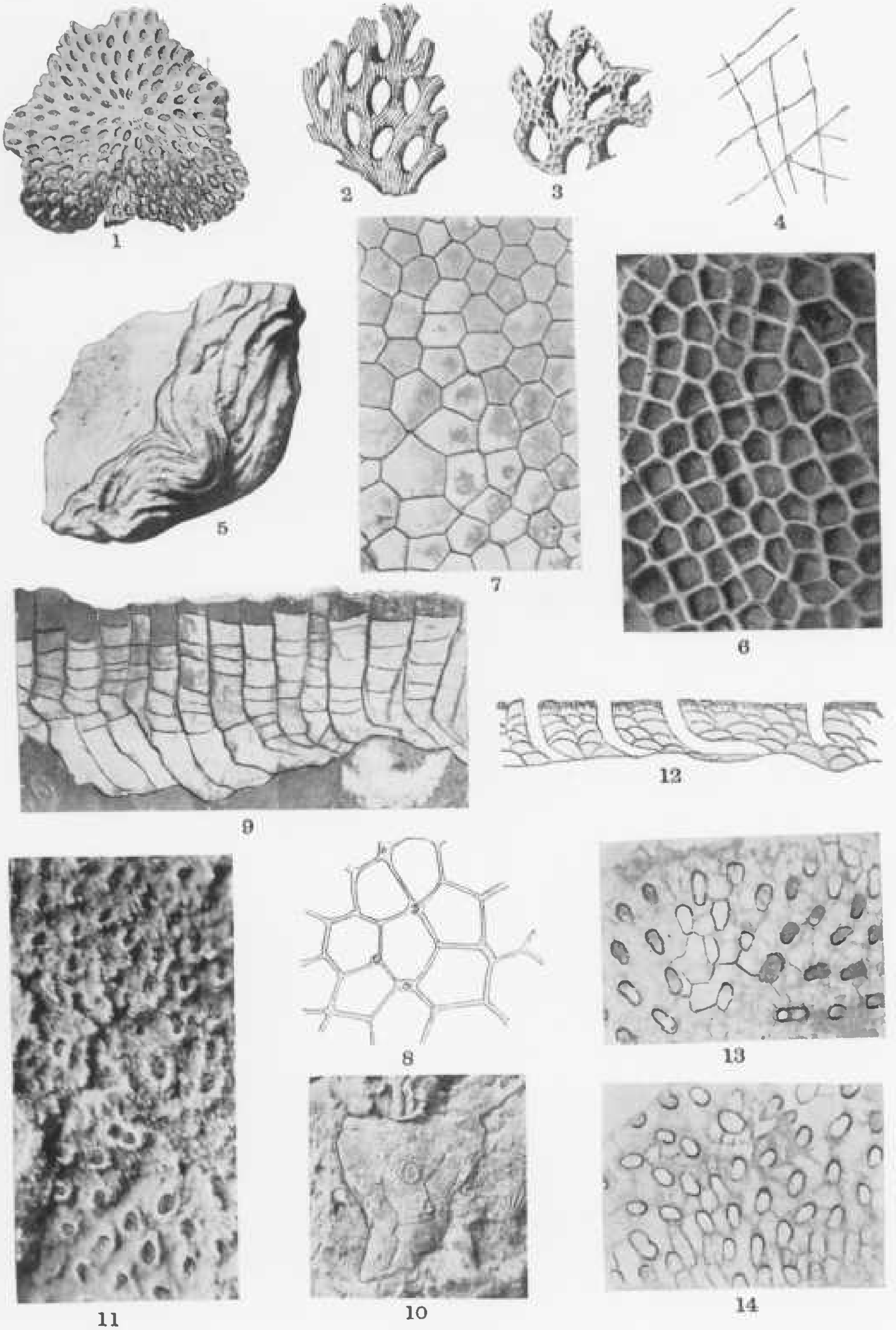
Tonoloway formation, lower part, 285 feet below top, Keyser, W. Va.

FIGS. 10-14. FISTULIPORELLA TENUILAMELLATA n. sp. 406

10. Fragment of the thin unilamellate zoarium on surface of limestone slab, ×1½.
11. Celluliferous surface. The small oval zooecia although poorly preserved show (1) their anterior half raised into a lunarium, (2) their radiation from a macula or noncelluliferous area and (3) the granular interspaces closed at the surface, × 20.
12. Vertical thin section, showing the vesiculose interspaces, × 20.

13, 14. Portions of a tangential section, × 20.

Tonoloway formation, lower part, 285 feet below top, Keyser, W. Va.



BRYOZOA.

PLATE XIV

PAGE

FIGS. 1-6. RHOMBOTRYPA RAMULOSA n. sp. 409

1. The small slender branching zoarium, $\times 1\frac{1}{2}$.
2. Zooecial surface with the apertures thin-walled and arranged in indistinct quincunx, $\times$ 20.
3. Photograph of tangential section, $\times$ 20.
4. Drawing of tangential section, showing the simple zooecial structure and the small acanthopores, $\times$ 35.
5. Transverse thin section, $\times$ 20.
6. Vertical thin section through a branching fragment, $\times$ 20.

Tonoloway formation, lower part, 285 feet below top, Keyser, W. Va.

FIG. 7. LEPTOTRYPA SILURICA n. sp. 408

The delicate incrusting zoarium, $\times$ 20.

Tonoloway formation, lower part, 285 feet below top, Keyser, W. Va.

FIGS. 8-12. LIOCLEMA TENUIRAMA n. sp. 408

8. Tangential thin section showing arrangement of zooecia, mesopores and acanthopores, $\times$ 20.
9. Portion of the same, illustrating the structure in more detail, $\times$ 35.
10. Transverse thin section, $\times$ 20.

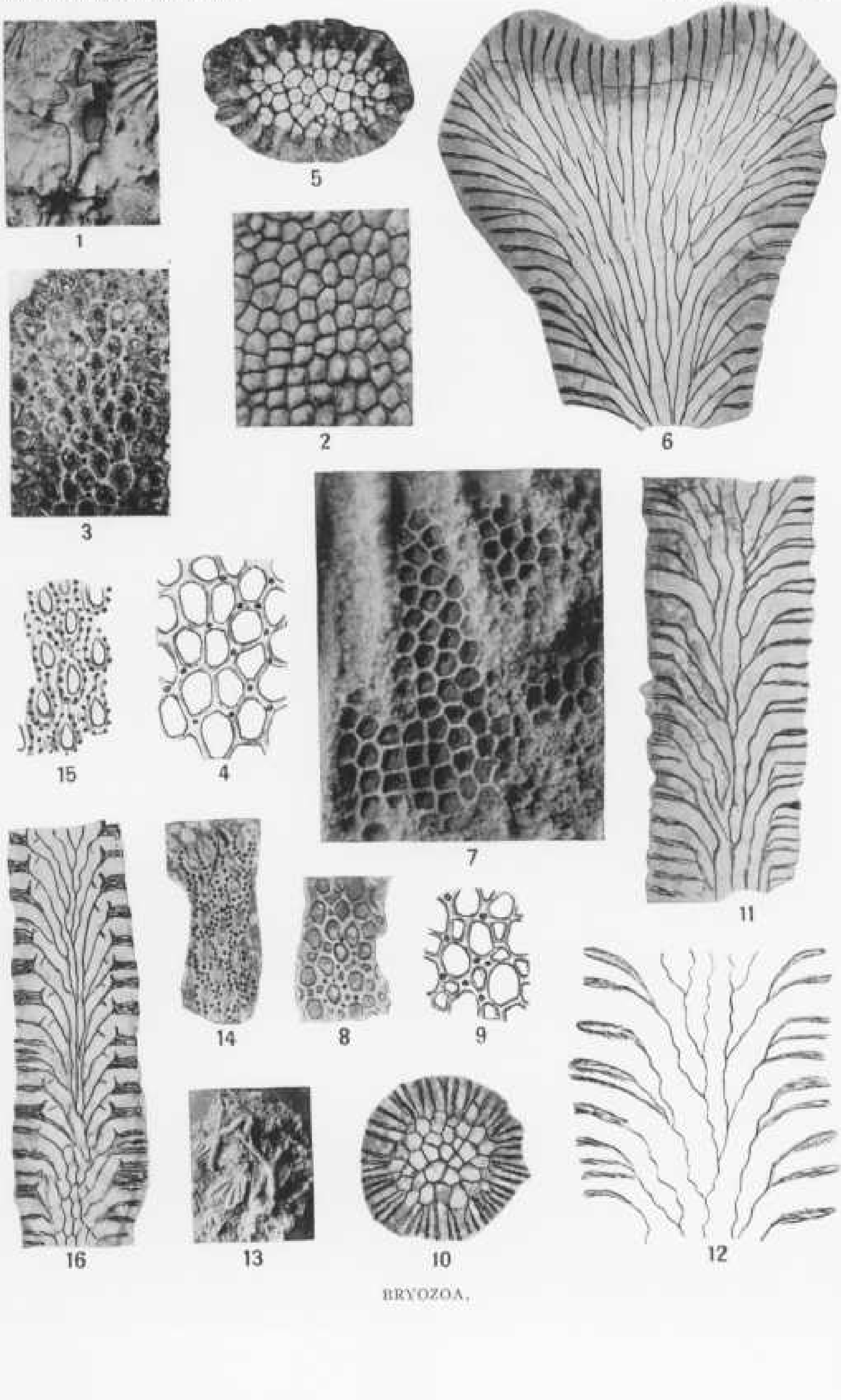
11, 12. Vertical thin section, $\times$ 20 and a portion $\times$ 35. The crinkled walls of the immature zone, the absence of diaphragms and the structure of the zooecia, mesopores and acanthopores in the mature zone are to be noted.

Tonoloway formation, lower part, 285 feet below top, Keyser, W. Va.

FIGS. 13-16. ORTHOPORA TONOLOWAYENSIS n. sp. 410

13. Two fragments of the small, solid, cylindrical branching zoarium, $\times 1\frac{1}{2}$.
14. Tangential thin section, through the mature zone, exhibiting the numerous spines or small acanthopores surrounding the aperture, $\times$ 20.
15. Portion of the same section, showing the microscopic structure in more detail, $\times$ 35.
16. Vertical thin section, illustrating the development of both superior and inferior hemisepta, $\times$ 20.

Tonoloway formation, lower part, 285 feet below top, Keyser, W. Va.



BRYOZOA.

PLATE XV

PAGE

FIGS. 1, 2. LINGULA CLARKI Prouty 412
1. View of valve.
2. Surface of same showing ornamentation, × 10.
McKenzie formation, Cedar Cliff, Md.

FIGS. 3, 4. LINGULA SUBTRUNCATA Prouty 413
3. View of valve.
4. Surface of same showing ornamentation, × 10.
McKenzie formation, Flintstone Creek, Md.

FIGS. 5-7. LINGULA sp. 414
5. View of partially exfoliated valve.
6. Same, × 2.
7. Exterior of valve which has been crushed, × 2.
Wills Creek formation, Bloomsburg member, Round Top, Md.

FIGS. 8-10. ORBICULOIDEA CLARKI Prouty 414
8. Large ventral valve and profile of same.
McKenzie formation, Cedar Cliff, Md.
9. Small dorsal valve and profile of same.
10. Small ventral valve.
McKenzie formation, Six-Mile House, Md.

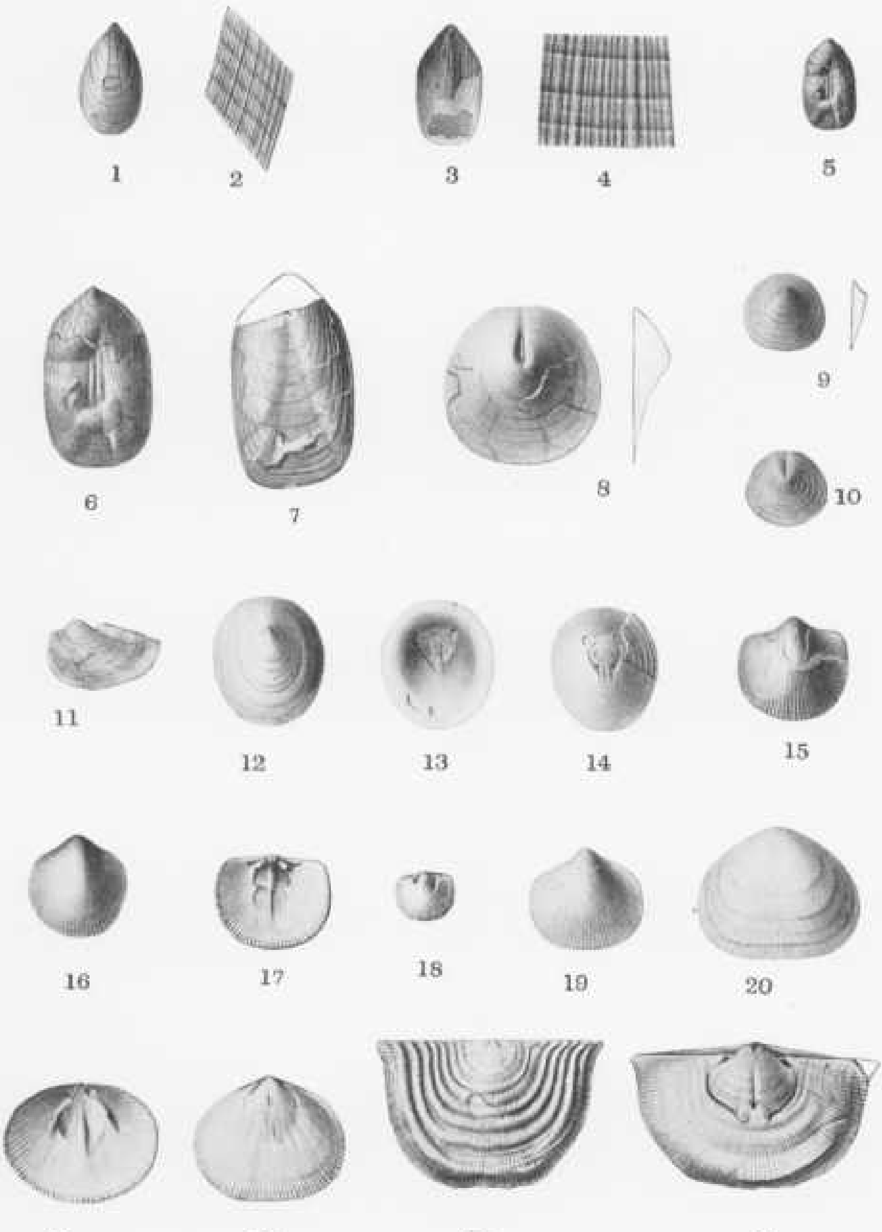
FIG. 11. ORBICULOIDEA sp. 415
Fragment of a crushed dorsal valve.
Tonoloway formation, Pinto, Md.

FIGS. 12-14. PHOLIDOPS SQUAMIFORMIS Hall 415
12. Exterior of dorsal valve, × 6.
Rochester formation, Cumberland, Md.
13. Interior of ventral valve, showing muscle scars, × 6.
14. Internal cast of ventral valve, × 6.
Rochester formation, Rose Hill, Md.

FIGS. 15-18. DALMANELLA ELEGANTULA (Dalman) 416
15. Ventral valve.
16. Internal cast of ventral valve.
Rochester formation, Six-Mile House, Section A.
17. Interior of dorsal valve.
Rochester formation, Sir Johns Run, Md.
18. Internal cast of dorsal valve.
Rochester formation, Cumberland, Md.

FIGS. 19-22. RHIPIDOMELLA HYBRIDA (Sowerby) 417
19. Ventral valve.
Rochester formation, Pinto, Md.
20. Ventral valve.
Rochester formation, Six-Mile House, Section B.
21. Internal cast of dorsal valve.
Rochester formation, Six-Mile House, Section A.
22. Internal cast of ventral valve.
Rochester formation, Cumberland, Md.

FIGS. 23, 24. LEPTÆNA RHOMBOIDALIS (Wilckens) 418
23. Dorsal valve.
Rochester formation, Six-Mile House, Md.
24. Internal cast of ventral valve.
Rochester formation, Cumberland, Md.



BRACHIOPODA.

PLATE XVI

PAGE

FIGS. 1-3. STROPHEODONTA DEFLECTA Prouty 423

1. Internal cast of dorsal valve.
2. Internal cast of ventral valve.
3. Same, × 2.

Rochester formation, Rose Hill, Md.

FIGS. 4-9. STROPHEODONTA CORRUGATA (Conrad) 420

4. Internal cast of ventral valve.
5. Internal cast of ventral valve.
6. Internal cast of ventral valve.

Rochester formation, Cumberland, Md.

7. Surface not exfoliated, × 15.
8. Surface somewhat exfoliated, × 15.
9. Surface greatly exfoliated, × 15.

Rochester formation, Rose Hill, Md.

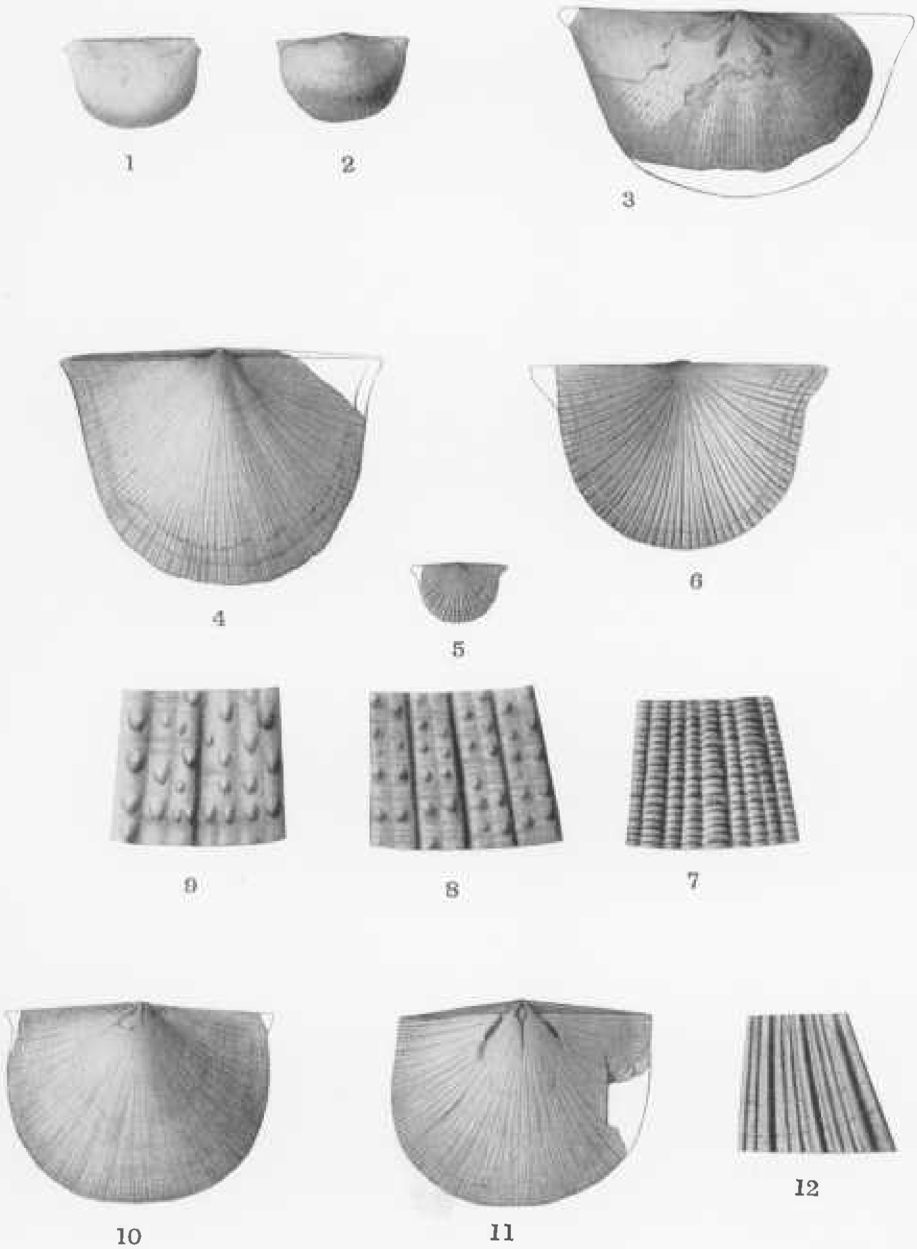
FIGS. 10-12. STROPHEODONTA CORRUGATA var. PLEURISTRIATA Foerste 421

10. Exterior of dorsal valve.
11. Portion of surface of same, × 10.

Rochester formation, Rose Hill, Md.

12. Internal cast of ventral valve, × 15.

Rochester formation, Cumberland, Md.



BRACHIOPODA.

PLATE XVII

PAGE

FIGS. 1-5. STROPHEODONTA CONVEXA Prouty 422

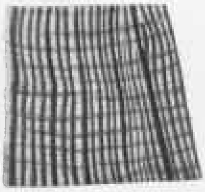
1. Valve partially exfoliated.
2. Interior of valve showing muscle scars.
3. Portion of surface shown in Fig. 1, showing ornamentation, × 8.
4. Portion of interior shown in Fig. 1, × 8.
5. Hinge of valve, × 2.

Rochester formation, Flintstone Creek, Md.

FIGS. 6, 7. STROPHEODONTA ACUMINATA Prouty 424

6. Interior of dorsal valve.
7. Slab showing two valves associated with numerous other species of the Rochester formation.

Rochester formation, Cumberland, Md.



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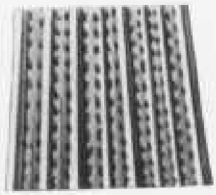

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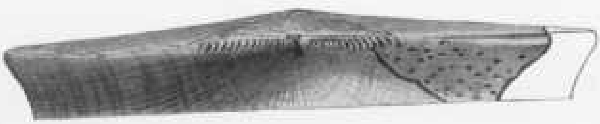

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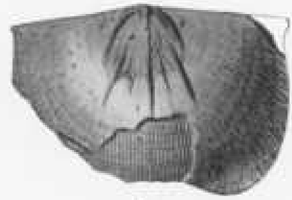

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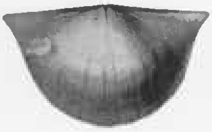

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BRACHIOPODA.

PLATE XVIII

PAGE

FIGS. 1-3. STROPHEODONTA VARISTRIATA (Conrad) 424

1. Ventral valve partially exfoliated showing muscular scars.
2. View of same, × 2.
3. Internal cast of ventral valve, × 2.

Tonoloway formation, National Road on Martin Mountain, Md.

FIG. 4. STROPHEODONTA (LEPTOSTROPHIA) BIPARTITA var. NEARPASSI Swartz 426

Cast of ventral valve. This figure does not show well the distinct curvature of the radiating striæ.

Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

FIGS. 5-7. SCHUCHERTELLA SUBPLANA (Conrad) 427

5. Ventral valve.

Rochester formation, Six-Mile House, Section B.

6. Exfoliated ventral valve.
7. Small ventral valve with rounded cardinal angles.

Rochester formation, Rose Hill, Md.

FIGS. 8-11. SCHUCHERTELLA TENUIS Hall 428

8. Ventral valve.
9. Part of surface of same, × 10.

Rochester formation, Six-Mile House, Section B.

10. Exfoliated ventral valve.
11. Surface of same, × 10.

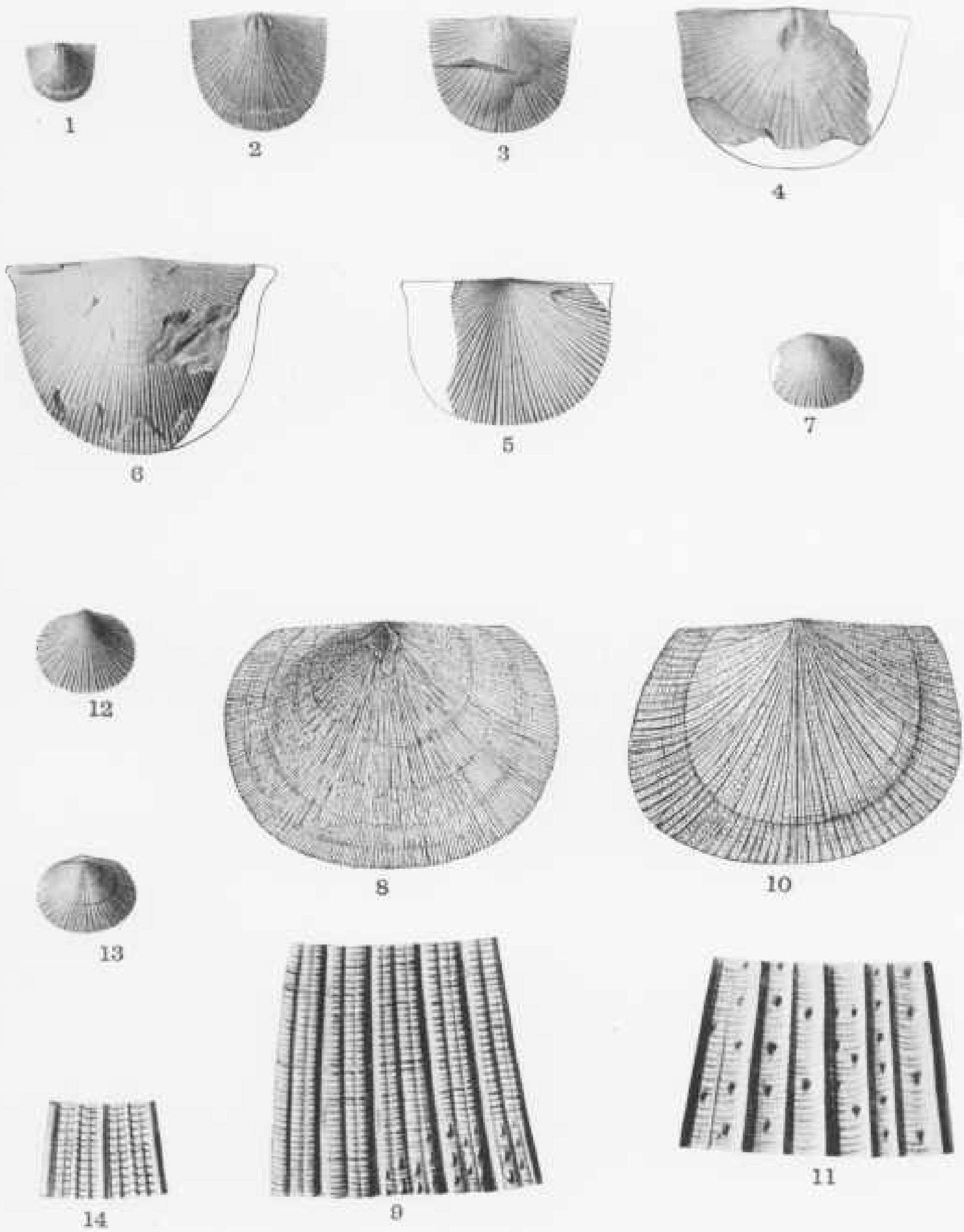
Rochester formation, Rose Hill, Md.

FIGS. 12-14. SCHUCHERTELLA ELEGANS Prouty 429

12, 13. Ventral and dorsal views.

14. Part of surface of same, × 10.

Rochester formation, Six-Mile House, Section B.



BRACHIOPODA.

PLATE XIX

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FIGS. 1-4. SCHUCHERTELLA INTERSTRIATA (Hall) 430

1. Dorsal valve, × 2.
2. Ventral valve, × 2.
3. Ventral valve, × 2.
4. Dorsal valve.

Wills Creek formation, Flintstone Creek, Md.

FIGS. 5-16. SCHUCHERTELLA RUGOSA Swartz 431

5. Dorsal view of type.

6, 7. Dorsal and ventral views of type, × 2.

8, 9, 10. Ventral, side and cardinal views, × 2.

11. Dorsal valve.
12. Dorsal valve having a long hinge line, × 2.
13. Interior of dorsal valve, × 2.
14. Same, showing hinge, × 6.
15. Interior of ventral valve, × 2.
16. Same, showing hinge, × 6.

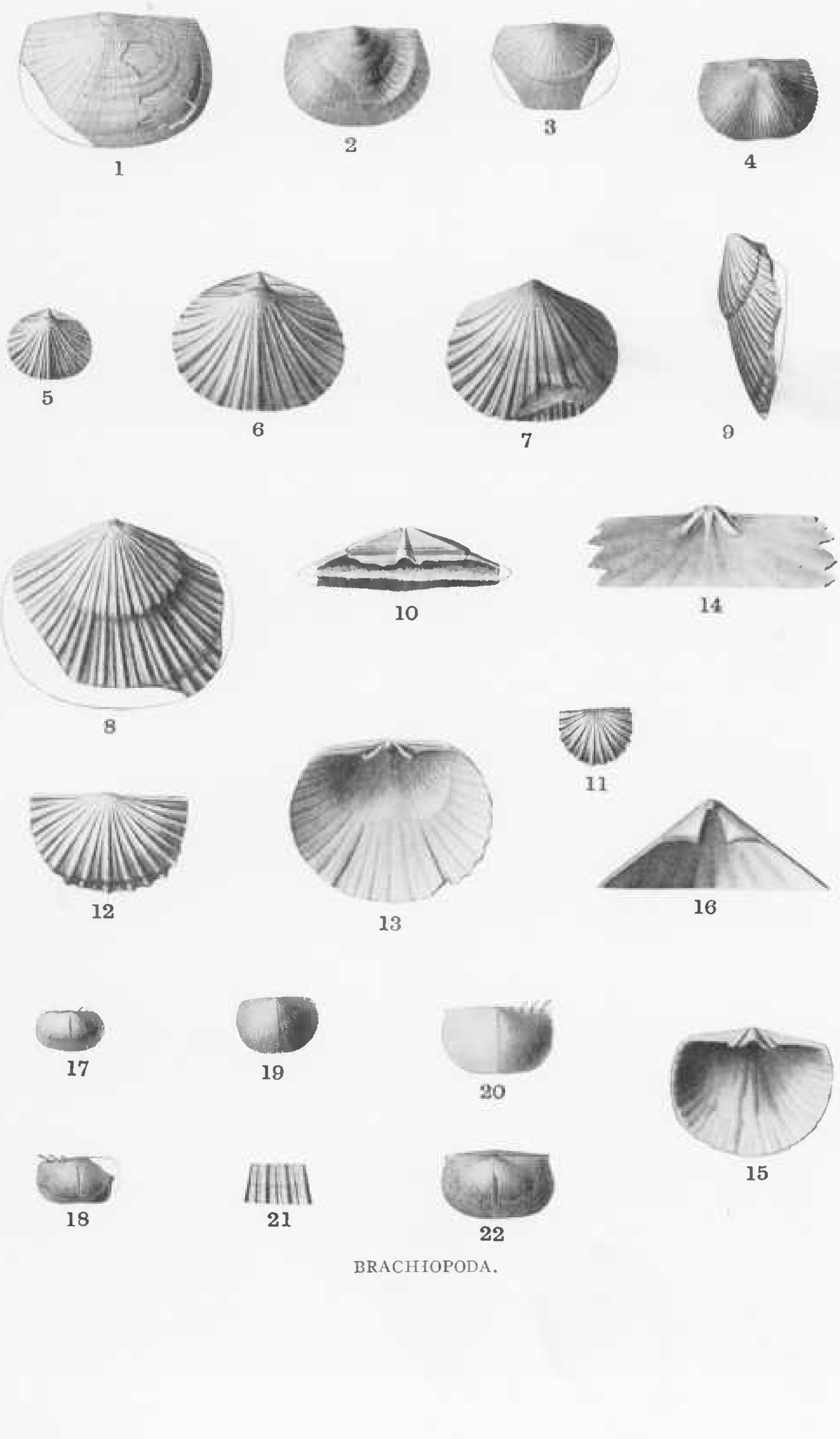
Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

FIGS. 17-22. CHONETES NOVASCOTICUS Hall 422

17, 18. Dorsal and ventral valves showing spines.

19. Dorsal valve.
20. Ventral valve, × 2.
21. Surface showing ornamentation, × 12.
22. Dorsal valve, × 2.

Rose Hill formation, Flintstone Creek, 6 feet below Keefer sandstone.



BRACHIOPODA.

PLATE XX

PAGE

FIGS. 1-7. STENOCHISMA (?) LAMELLATA (Hall) 434

1. Dorsal view of type.
2-4. Ventral, dorsal and side views of same, × 2.
5. Interior of ventral valve, umbo broken, × 3.
6. Interior of dorsal valve showing hinge, × 3.
7. Interior of dorsal valve showing hinge and faint median septum.

Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

FIG. 8. CONCHIDIUM CUMBERLANDICUM Prouty 433

Internal cast of dorsal valve.

Rose Hill formation, Cumberland, Md.

FIGS. 9-14. UNCINULUS MARYLANDICUS Swartz 435

9, 10. Ventral and dorsal views of type.
11. Ventral valve, broken at umbo.
12-14. Ventral, dorsal and front views, × 1½.

Tonoloway formation, Grasshopper Run, W. Va.

FIGS. 15-19. UNCINULUS OBSOLESCENS Swartz 436

15. Ventral valve exfoliated at umbo.
16-18. Ventral, dorsal and front views of type, × 2.
19. Internal cast of large ventral valve questionably referred to this species.

Wills Creek formation, Flintstone Creek, Md.

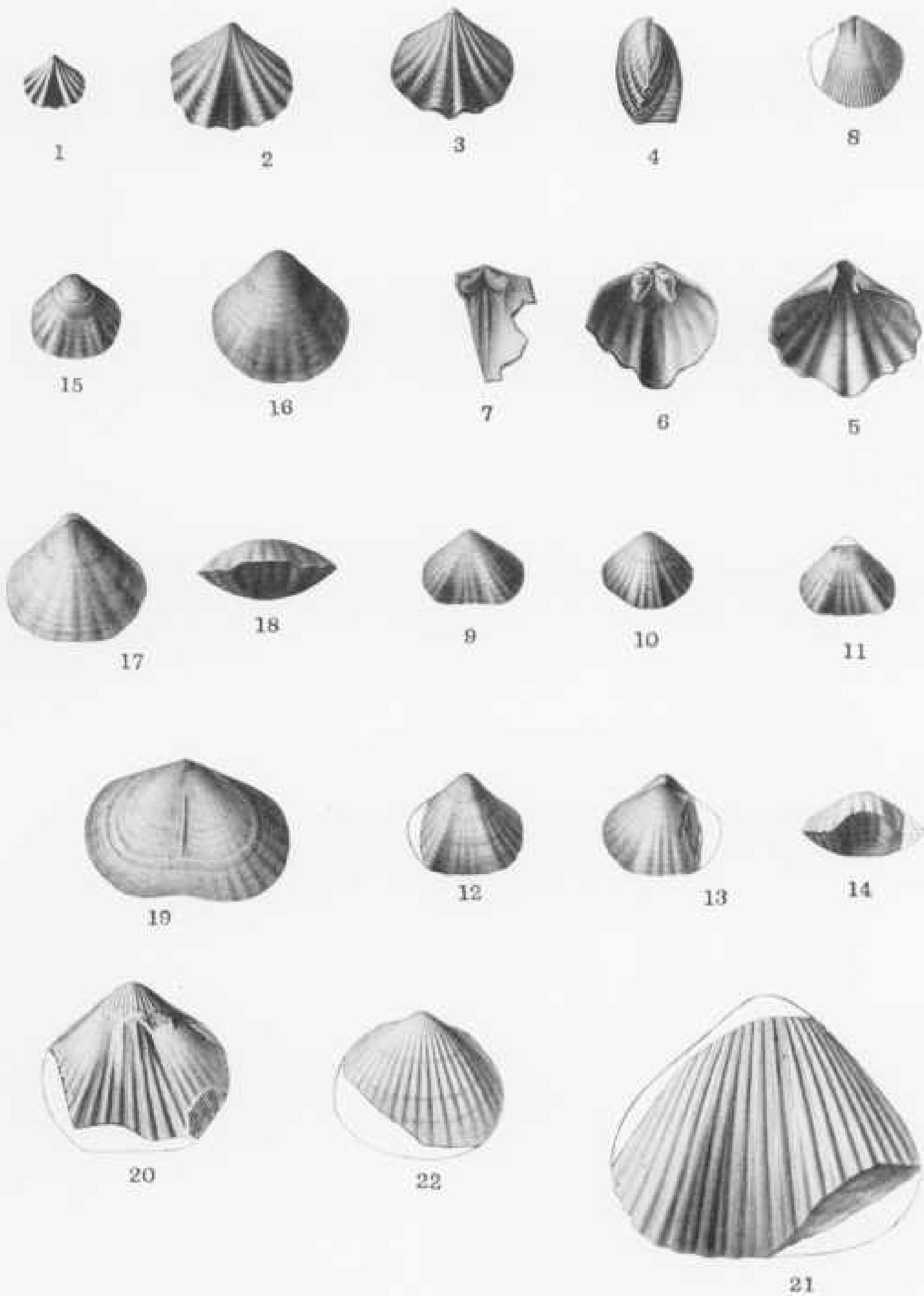
FIGS. 20-22. UNCINULUS cf. STRICKLANDI (Sowerby) 437

20. Internal cast of small ventral valve.
21. Large ventral valve.

Rochester formation, Rose Hill.

22. Small ventral valve.

Rochester formation, Six-Mile House, Md.



BRACHIOPODA.

PLATE XXI

PAGE

FIGS. 1-3. UNCINULUS cf. STRICKLANDI (Sowerby) 437

1. Internal cast of small ventral valve.
2. Internal cast of dorsal valve of medium size.
   Rochester formation, Six-Mile House, Section A.
3. Front view of shell.
   Rochester formation, Flintstone Creek, Md.

FIGS. 4-12. UNCINULUS OBTUSIPLICATUS (Hall) 438

4. Dorsal view of small internal cast.
5, 6. Dorsal and front views of internal cast.
7, 8. Ventral and dorsal views.
9. Ventral valve.
10, 11. Side and front views of gibbous shell.
12. Plications of ventral sinus, $\times$ 3.
   McKenzie formation, Cedar Cliff, Md.

FIGS. 13-19. CAMAROTOECHIA ANDREWSI Prouty 439

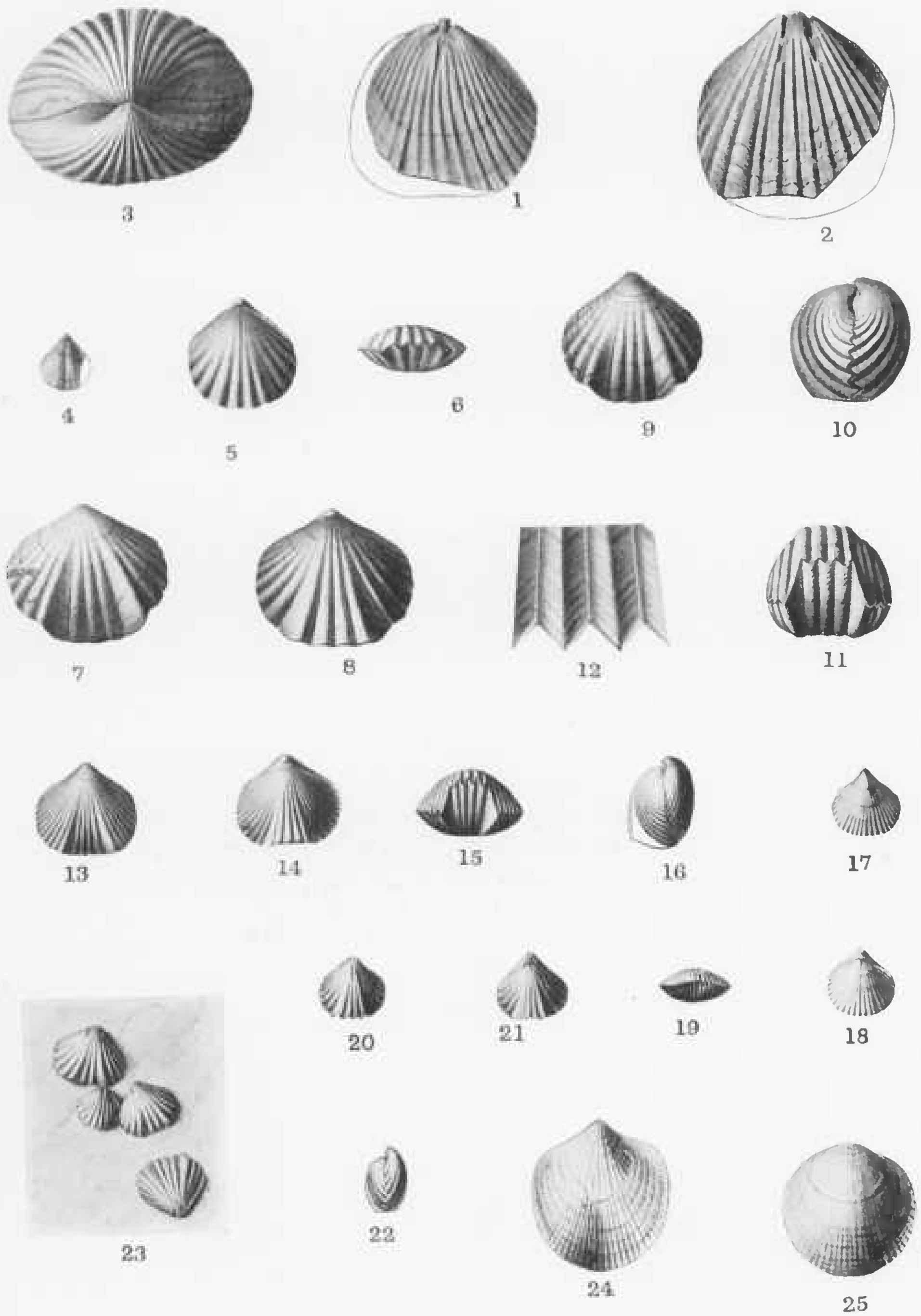
13-16. Ventral, dorsal, front and side views of adult.
17-19. Ventral, dorsal and front view of internal cast of young shell.
   McKenzie formation, Cedar Cliff, Md.

FIGS. 20-23. CAMAROTOECHIA NEGLECTA Hall 440

20. Dorsal view of internal cast.
21, 22. Dorsal and side views of internal cast.
23. Internal casts of several shells.
   Rochester formation, Cumberland, Md.

FIGS. 24, 25. ATRYPA RETICULARIS (Linné) 444

24, 25. Ventral and dorsal views.
   Rochester formation, Rose Hill, Md.



BRACHIOPODA.

PLATE XXII

PAGE

FIGS. 1-6. CAMAROTOECHIA LITCHFIELDENSIS (Schuchert)............... 441

1. Ventral view.

2, 3. Ventral and dorsal views of same, × 2.

Tonoloway formation, Pinto, Md.

4-6. Ventral, dorsal and side views, × 2.

Wills Creek formation, Flintstone Creek, Md.

FIGS. 7-13. CAMAROTOECHIA LITCHFIELDENSIS var. MARYLANDICA Swartz... 443

7. Ventral view.

8. Same, × 2.

9, 10. Ventral and side views of type.

Tonoloway formation, Grasshopper Run, W. Va.

11-13. Ventral, dorsal and front views of same, × 2.

Tonolway formation, Quarry of Standard Lime and Stone Co., Keyser, W. V.

FIGS. 14-20. CAMAROTOECHIA TONOLOWAYENSIS Swartz.................. 443

14, 15. Ventral and dorsal views.

16, 17. Ventral and dorsal views of an imperfect specimen.

18. Large dorsal valve.

Tonoloway formation, Pinto, Md.

19, 20. Ventral and front view of type, × 2.

Tonoloway formation, Grasshopper Run, W. Va.

FIGS. 21-30. SPIRIFER MCKENZICUS Prouty............................. 446

21-24. Ventral, dorsal, side, and cardinal views.

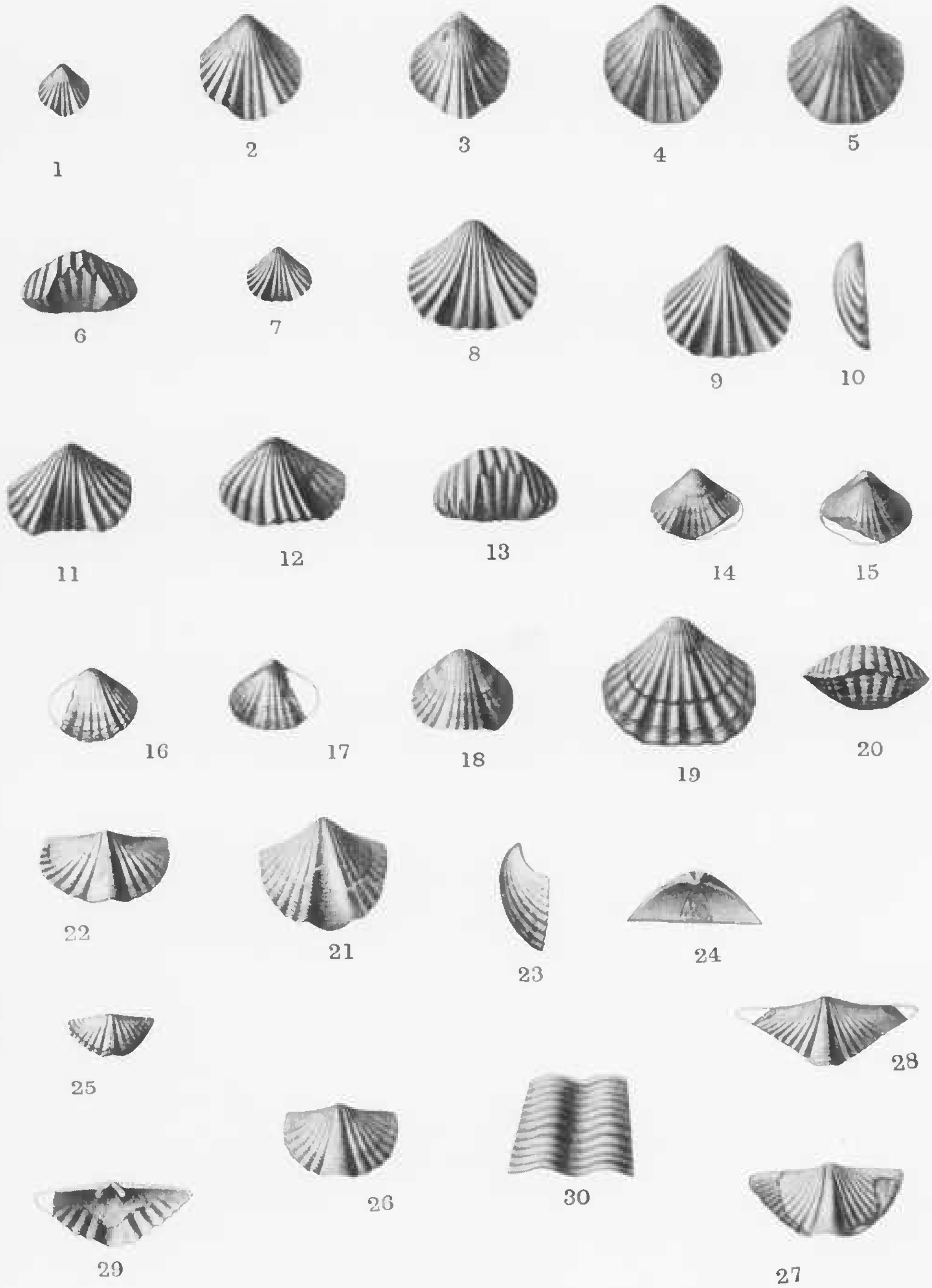
McKenzie formation, Grasshopper Run, W. Va.

25-28. Ventral valves of various proportions.

29. Interior of dorsal valve.

30. Exterior of dorsal valve shown in Fig. 26 to show ornamentation, × 6.

McKenzie formation, Flintstone Creek, Md.



BRACHIOPODA.

PLATE XXIII

PAGE

FIGS. 1-4. SPIRIFER (DELTHYRIS) CRISPUS (Hisinger) 447

1. Ventral valve.
2. Internal cast of ventral valve.
3. Internal cast of dorsal valve.
4. Surface of valve shown in Fig. 2 to show ornamentation, × 4.

Rochester formation, Cumberland, Md.

FIGS. 5-9. SPIRIFER (DELTHYRIS) VANUXEMI Hall 447

5. Ventral valve.
6. Same, ×2.

Tonoloway formation, Grasshopper Run, W. Va.

7, 8, 9. Ventral, dorsal and side views, × 2.

Wills Creek formation, Flintstone Creek, Md.

FIGS. 10, 11. SPIRIFER (DELTHYRIS) VANUXEMI var. TONOLOWAYENSIS Swartz 449

10. Internal cast of ventral valve.
11. Same, × 2.

Tonoloway formation, Mullens Quarry, Cumberland, Md.

FIG. 12. SPIRIFER (DELTHYRIS) VANUXEMI var. 449

Internal cast of dorsal valve, × 2.

Keyser limestone member of Helderberg formation, Grasshopper Run, W. Va.

FIGS 13, 14. SPIRIFER (DELTHYRIS) KEYSERENSIS Swartz............... 449

13. Ventral valve.
14. Dorsal valve.

Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

FIGS. 15-18. SPIRIFER (DELTHYRIS) CORALLINENSIS Grabau 451

15. Internal cast of ventral valve.
16. Same, × 2.
17. Dorsal valve, × 2.
18. Ventral valve showing plications, × 2.

Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

FIGS. 19, 20. SPIRIFER (EOSPIRIFER) RADIATUS (Sowerby) 452

19. Internal cast of dorsal valve.
20. Part of surface of same showing ornamentation, × 6.

McKenzie formation, Flintstone Creek, Md.

FIGS. 21-25. SPIRIFER (EOSPIRIFER) EUDORA Hall 453

21-23. Front, side and cardinal views of exfoliated ventral valve.

McKenzie formation, Grasshopper Run, W. Va.

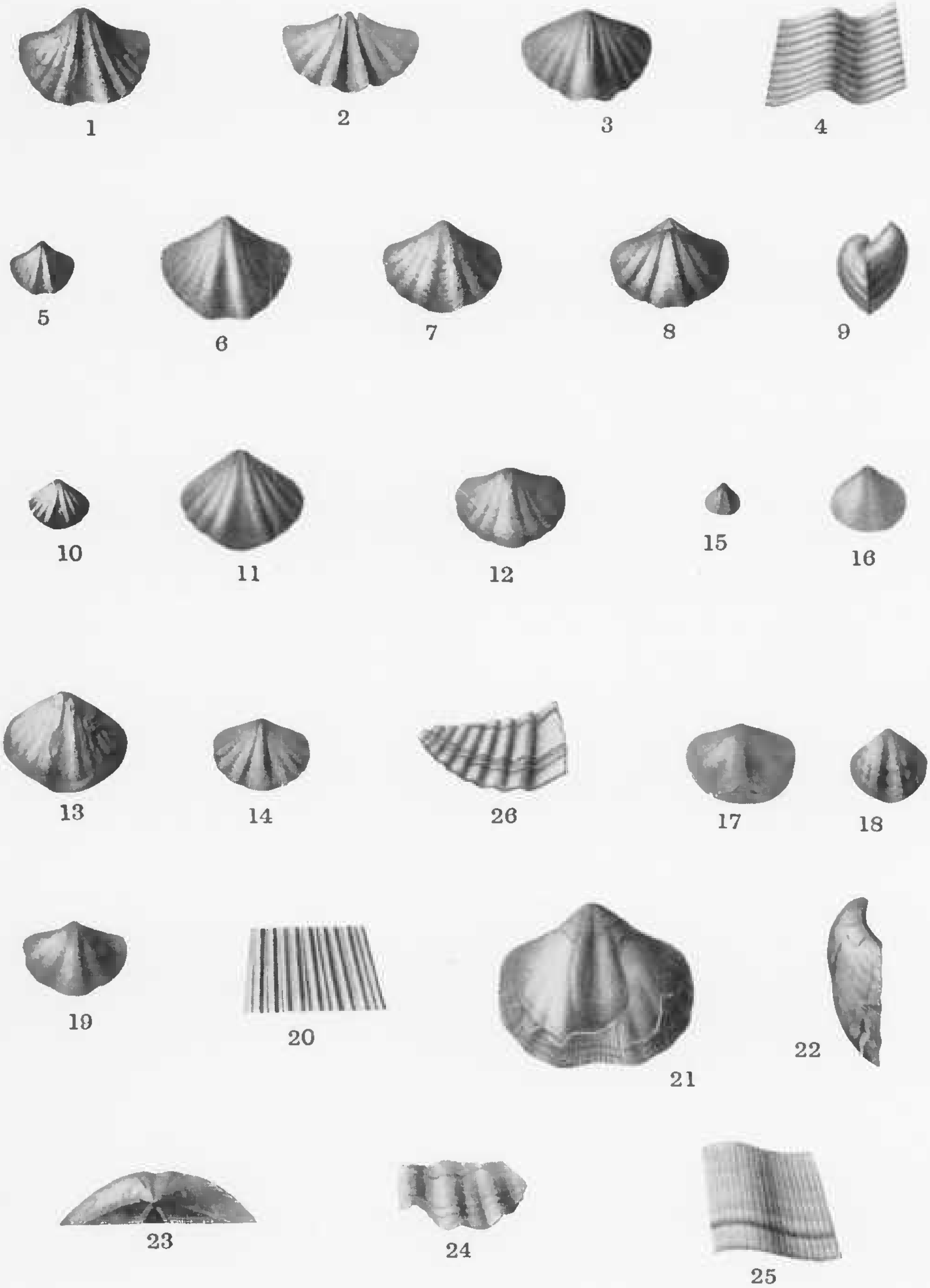
24. Fragment showing surface ornamentation.
25. Same, × 3.

Rochester formation, Flintstone Creek (Keefer sandstone), Md.

FIG. 26. SPIRIFER (EOSPIRIFER) NIAGARENSIS (Conrad) 454

Fragment of dorsal valve, showing ornamentation.

Rochester formation, Flintstone Creek (Keefer sandstone), Md.



BRACHIOPODA.

PLATE XXIV

PAGE

FIGS. 1-5. RETICULARIA BICOSTATA (Vanuxem)........................ 455

1, 2. Front and side views of small ventral valve.

3. Ventral valve of medium size.

4. Large ventral valve.

5. Small dorsal valve, × 3.

Rochester formation, Rose Hill, Md.

FIGS. 6-15. RETICULARIA BICOSTATA var. MARYLANDICA Prouty............ 456

6. Small ventral valve.

Rochester formation, Six-Mile House, Section B.

7. Large ventral valve.

Rochester formation, east of Tonoloway, Md.

8-10. Front, side and cardinal views of ventral valve, × 2.

11. Large dorsal valve.

Rochester formation, Rose Hill, Md.

12. Internal cast of ventral valve.

13. Interior of ventral valve showing cardinal area.

14. Interior of ventral valve, × 2.

15. Portion of exterior of valve shown in Fig. 8 showing ornamentation, × 10.

Rochester formation, Pinto, Md.

FIGS. 16-25. RHYNCHOSPIRA GLOBOSA (Hall)........................... 456

16-18. Ventral, dorsal and side views of medium-sized shell.

19, 20. Ventral and dorsal views of crushed large shell.

21, 22. Ventral and dorsal views of small internal cast.

23-25. Ventral, dorsal and front views of large internal cast.

Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

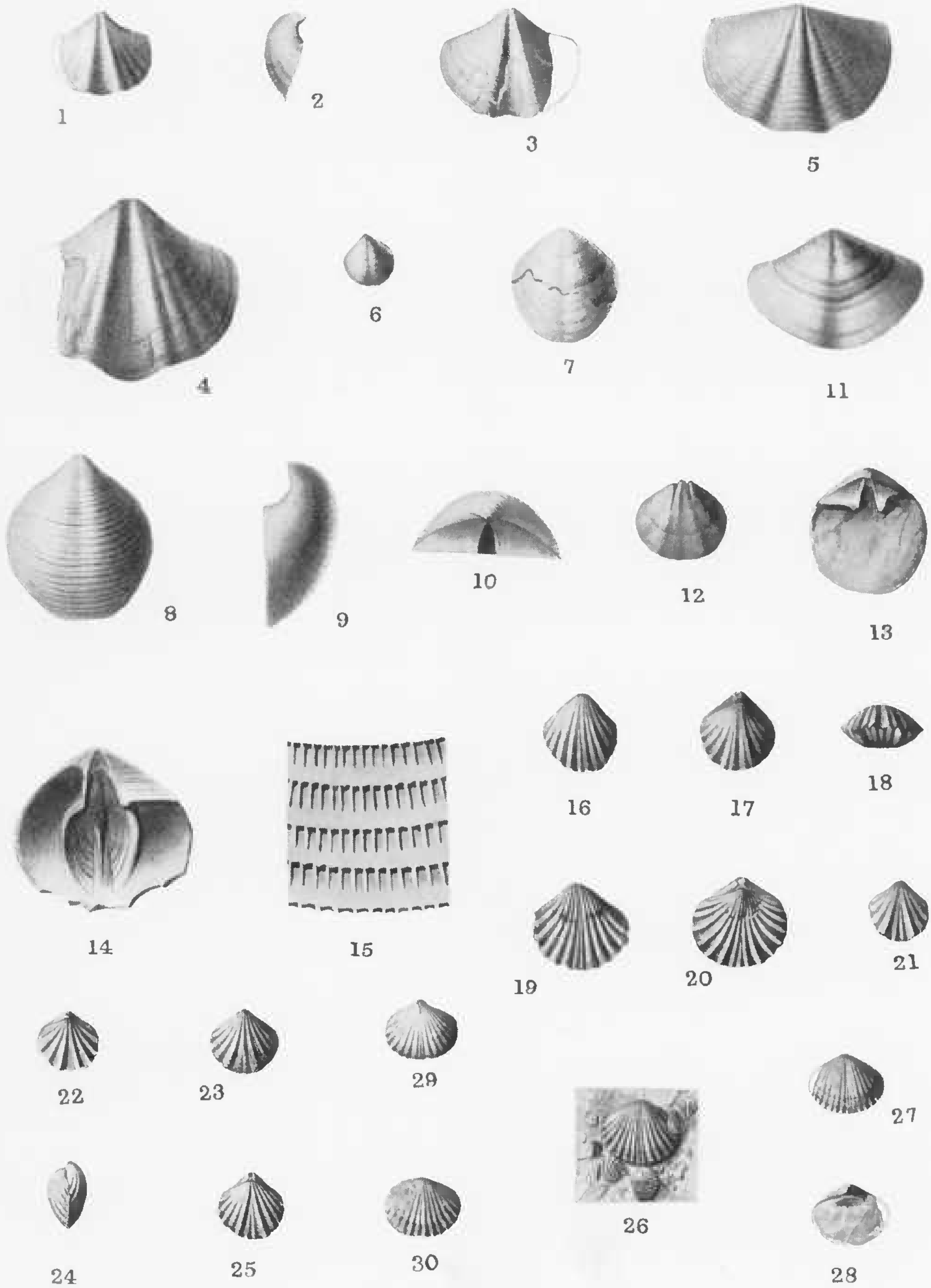
FIGS. 26-30. TREMATOSPIRA CAMURA Hall.............................. 458

26, 27. Ventral valves.

28. Interior of same.

29, 30. Ventral and dorsal views of shell.

Rochester formation, east of Tonoloway, Md.



BRACHIOPODA.

PLATE XXV

PAGE

FIGS. 1-9. HOMŒSPIRA EVAX var. MARYLANDICA Prouty................. 457

1-4. Ventral, dorsal, side and front views of shell.
5. Ventral valve.
6. Internal cast of ventral valve of different proportions.
7. Dorsal view of shell.
8. Dorsal view of shell.
9. Interior showing spirals.

McKenzie formation, Six-Mile House, Section A, about 150′ below top of McKenzie.

FIGS. 10-22. HINDELLA (GREENFIELDIA) CONGREGATA Swartz................ 459

10. Dorsal view of young shell.
11. Interior of dorsal valve showing hinge and faint median septum, × 5.

Tonoloway formation, Keyser-Heddenville Road, Keyser, W. Va.

12. Dorsal view of young shell.
13. Dorsal view of young shell of transverse type.
14. Internal cast of narrow shell.
15-17. Ventral, dorsal, and side views of large shell.

Tonoloway formation, Pinto, Md.

18-20. Ventral, dorsal and side views of internal cast of type.

Tonoloway formation, Baltimore Pike, 1½ miles west of Six-Mile House, Md.

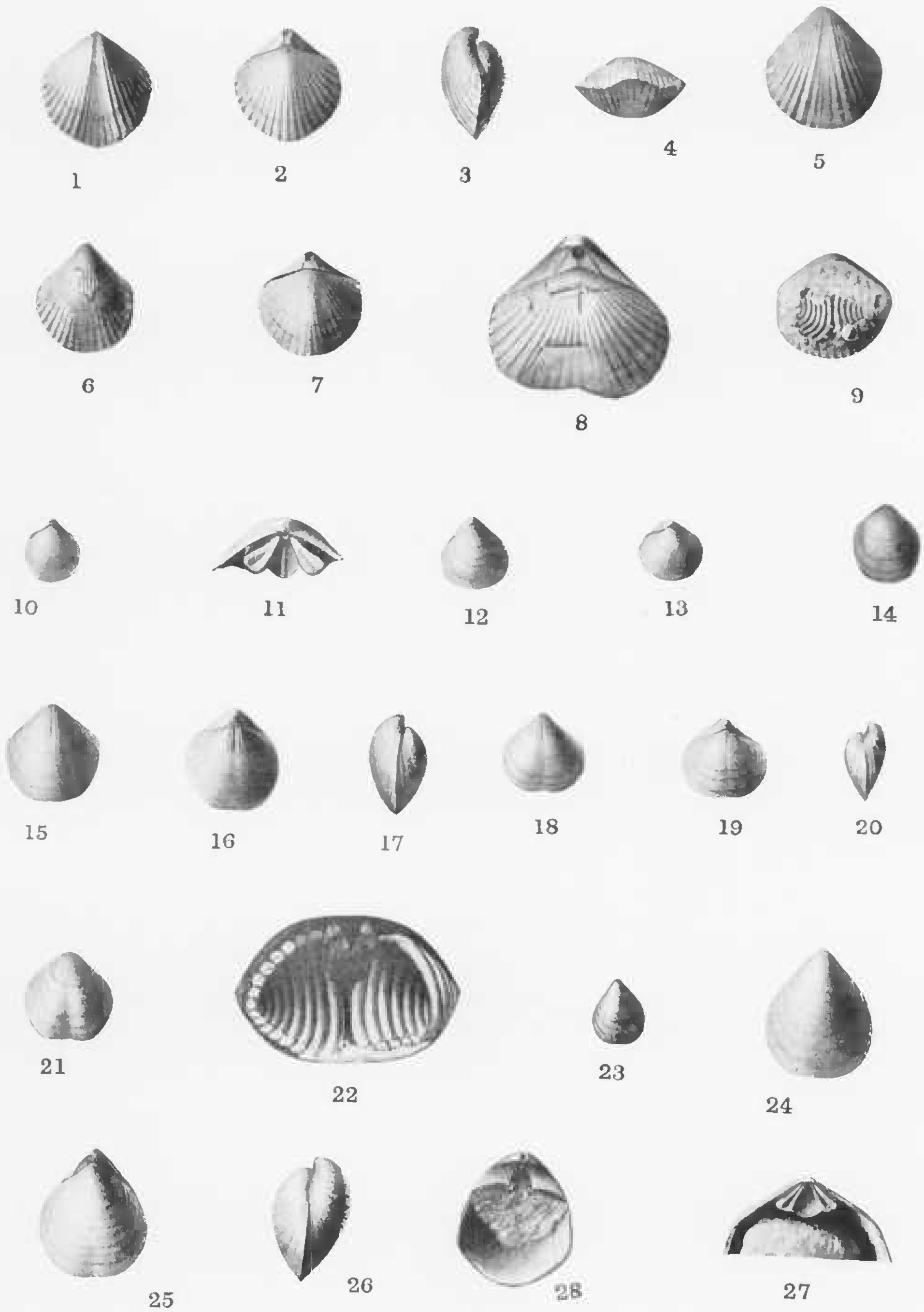
21. Ventral valve with deep sinus.
22. Interior showing spiral brachidia, × 3.

Tonoloway formation, Quarry of Standard Limestone Co., Keyser, W. Va.

FIGS. 23-28. HINDELLA (GREENFIELDIA) CONGREGATA var. INTERMEDIA Swartz 461

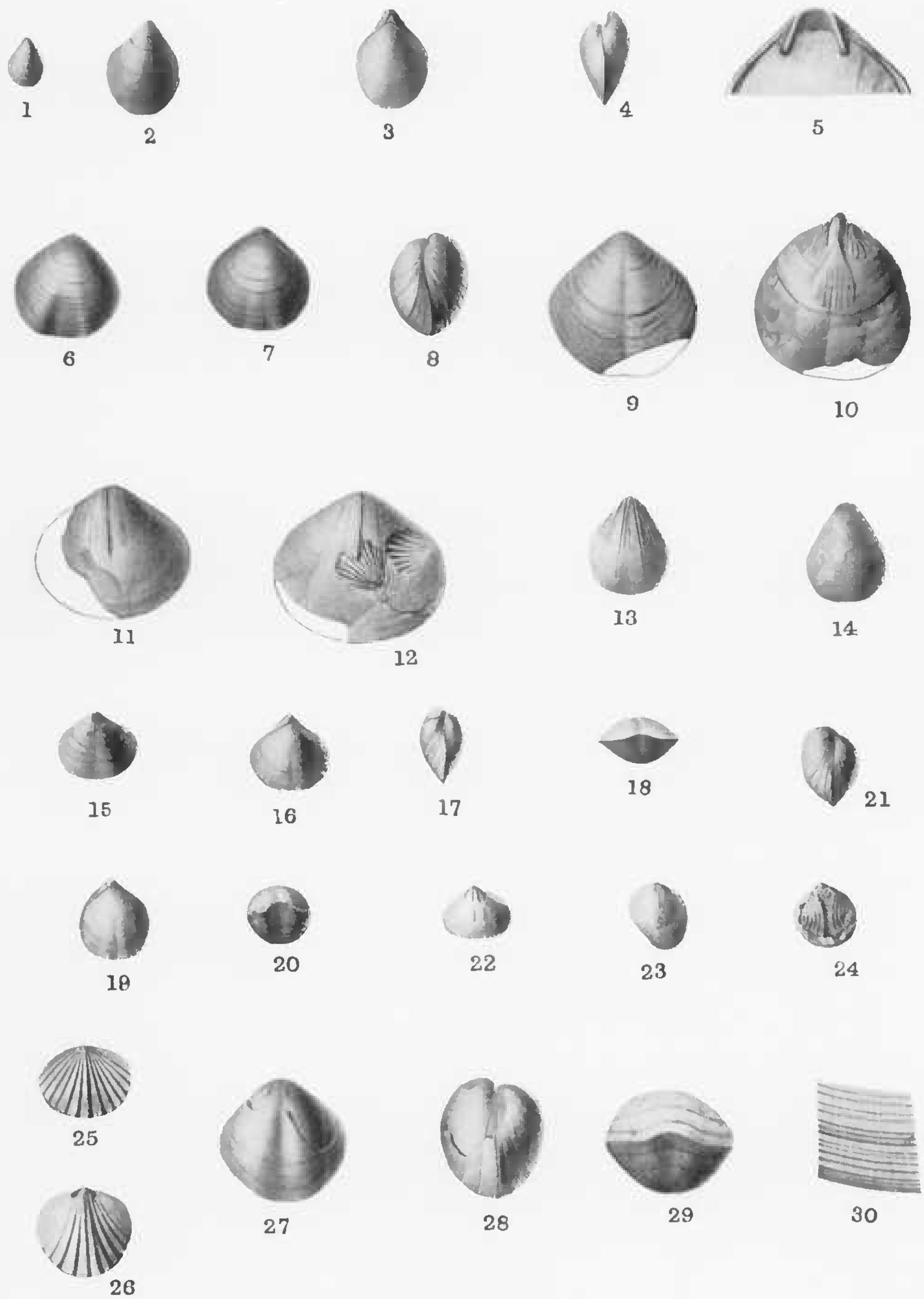
23. Ventral view of type.
24-26. Ventral, dorsal and side views of type, × 2.
27. Interior of ventral valve showing hinge, × 5.
28. Interior of ventral valve showing hinge, × 2.

Tonoloway formation, Mullens Quarry, Cumberland, Md.



BRACHIOPODA.

PLATE XXVI



BRACHIOPODA.

PLATE XXVII

PAGE

FIGS. 1-5. WHITFIELDELLA SUBOVATA Prouty.......................... 465
1-4. Ventral, dorsal, side and front views of type.
5. Dorsal view of a shell of slightly different proportions.
Rochester formation, Rose Hill, Md.

FIGS. 6-8. CŒLOSPIRA SULCATA Prouty.......................... 466
6. Ventral valve, × 2.
Rose Hill formation, Rose Hill, Md.
7. Internal cast of dorsal valve, × 2.
8. Internal cast of dorsal valve, × 2.
Rochester formation, Flintstone Creek, Md.

FIGS. 9, 10. CUNEAMYA ULRICHI Prouty.......................... 467
9. Cardinal view of internal cast of type.
10. Same from right side.
McKenzie formation, Cedar Cliff, Md.

FIG. 11. CTENODONTA SUBCIRCULARIS Prouty.......................... 469
Right valve.
Rochester formation, Cumberland, Md.

FIG. 12. GRAMYSIA KIRKLANDI Prouty.......................... 468
Internal cast of right valve.
Rose Hill formation, Devil's Nose, near Sir John's Run, W. Va.

FIGS. 13-15. CTENODONTA SUBRENIFORMIS Prouty.......................... 469
13, 14. Cardinal and anterior views of internal cast of type, × 2.
McKenzie formation, Flintstone Creek, Md.
15. Internal cast of right valve.
McKenzie formation, Cedar Cliff, Md.

FIGS. 16, 17. CTENODONTA WILLSI Prouty.......................... 470
16. Right valve.
17. Interior of same.
Rose Hill formation, Cumberland, Md.

FIG. 18. CTENODONTA OVATA Prouty.......................... 470
Internal cast of left valve.
Rochester formation, Six-Mile House, Section A.

FIGS. 19-21. CLIDOPHORUS NITIDUS Prouty.......................... 471
19. Left valve.
20. Internal cast of right valve.
McKenzie formation, Six-Mile House, Section A.
21. Internal cast of left valve.
McKenzie formation, Cedar Cliff, Md.

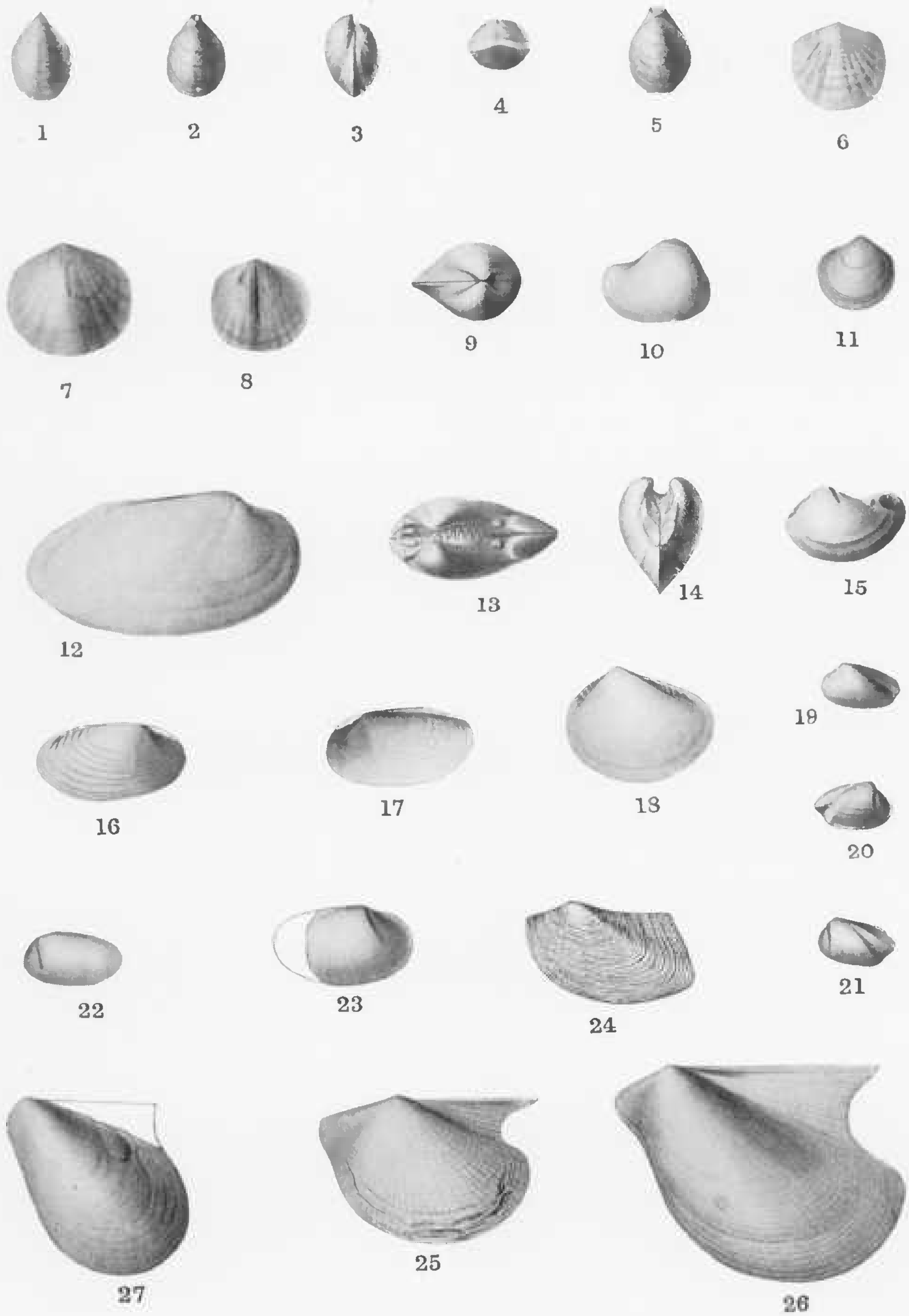
FIG. 22. CLIDOPHORUS SUBOLONGATUS Prouty.......................... 472
Internal cast of left valve of type.
Rose Hill formation, Grasshopper Run, W. Va.

FIG. 23. CLIDOPHORUS sp. 472
Imperfect internal cast of right valve.
McKenzie formation, Pinto, Md.

FIG. 24. PTERINEA ELONGATA Prouty 474
Left valve.
Rochester formation, Rose Hill, Md.

FIGS. 25, 26. PTERINEA EMACERATA (Conrad).......................... 473
25. Right valve.
Rochester formation, Six-Mile House, Section A.
26. Right valve, larger than the preceding and with more oblique body.
Rochester formation, Six-Mile House (Keefer sandstone), Section B.

FIG. 27. LEIOPTERIA (?) PENNSYLVANICA Swartz.......................... 477
Internal cast of left valve.
Tonoloway formation, Licking Creek, Warren Point, Pa.



BRACHIOPODA, MOLLUSCA.

PLATE XXVIII

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FIGS. 1-3. LEIOPTERIA SUBPLANA (Hall) 476

1. Left valve.
2. Imperfect left valve showing ornamentation.
3. Portion showing ornamentation, × 5.

Rochester formation, Six-Mile House, Section A.

FIGS. 4-8. MODIOLOPSIS GREGARIUS Swartz 478

4. Right valve of type.
5. Right valve, somewhat different form.

Tonoloway formation, north of gap in Shrivers Ridge, Pa.

6, 7. Right valve and cardinal view of internal cast, × 2.

Tonoloway formation, Pinto, Md.

8. Left valve.

Tonoloway formation, ¼ mile west of Hindman, Pa.

FIG. 9. MODIOLOPSIS CUMBERLANDICUS Prouty 479

Left valve.

Rochester formation, Cumberland, Md.

FIGS. 10, 11. MODIOLOPSIS cf. SUBCARINATUS Hall 480

10. Left valve.
11. Left valve of different proportions.

Rose Hill formation, Cumberland, Md.

FIGS. 12, 13. MODIOLOPSIS LEIGHTONI Williams (?) 480

12. Right valve.
13. Left valve.

Tonoloway formation, Pinto, Md.

FIGS. 14, 15. ORTHONOTA (?) MARYLANDICA Swartz 481

14. Left valve.
15. Same, × 2.

Tonoloway formation, Quarry west of Hancock, Md.

FIGS. 16-19. PTERINEA FLINTSTONENSIS Prouty 474

16. Small left valve.
17, 18. Large left valves.
19. Surface, × 5.

McKenzie formation, Flintstone Creek, Md.

FIGS. 20, 21. PTERINEA CANCELLATA Prouty 475

20. Left valve.
21. Surface showing ornamentation, × 6.

Rochester formation, Rose Hill, Md.

FIGS. 22-25. ACTINOPTERIA (?) sp. 476

22. Left valve.
23. Same, × 2.

Wills Creek formation, Wills Creek, Cumberland, Md.

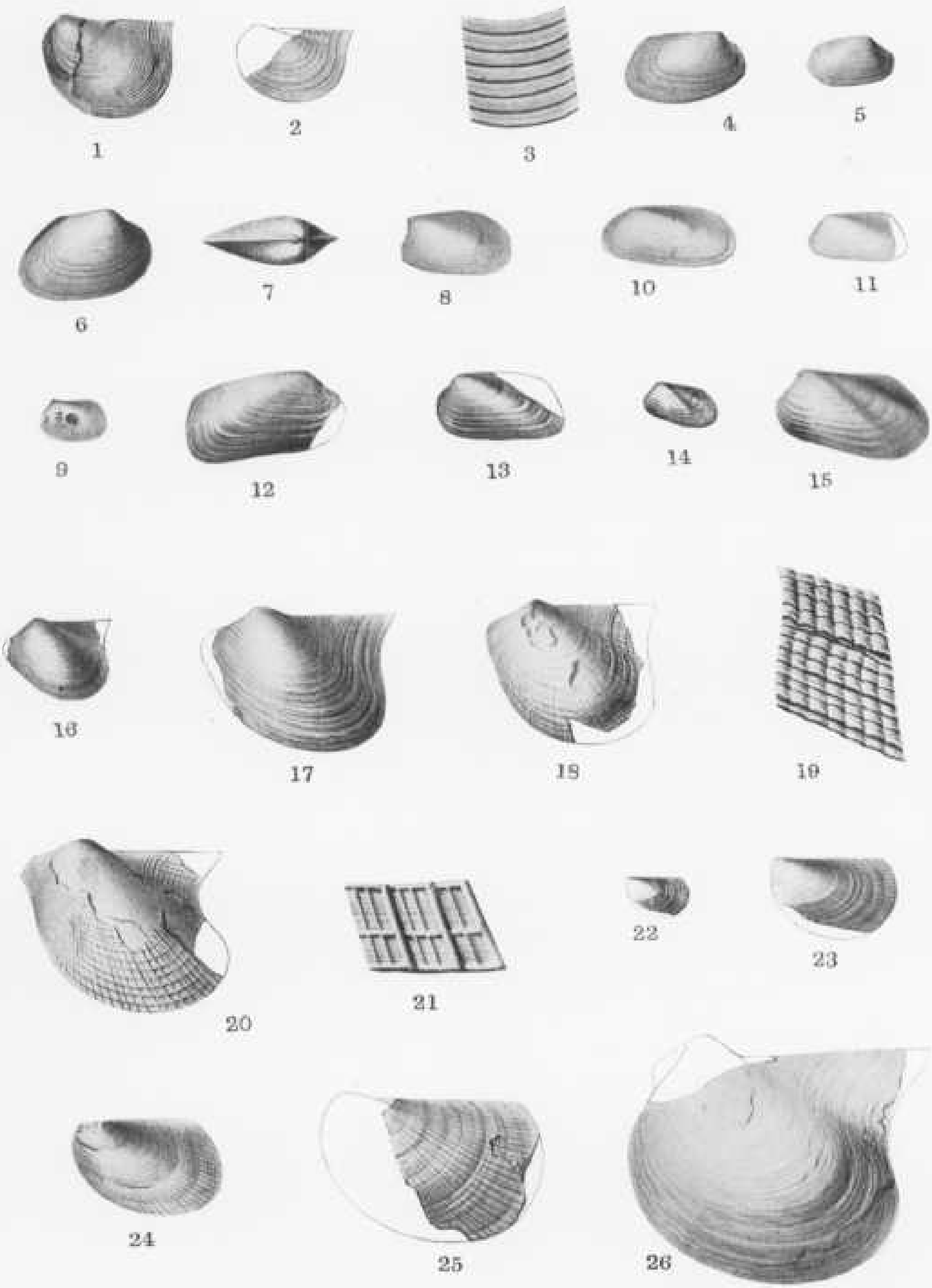
24. Left valve, × 2.
25. Fragment of left valve, × 2.

Wills Creek formation, Pinto, Md.

FIG. 26. LIOPTERIA sp. 478

Left valve.

McKenzie formation, Grasshopper Run, W. Va.



MOLLUSCA-PELECYPODA.

PLATE XXIX

PAGE

FIGS. 1-6. BUCANELLA TRILOBITA (Conrad) 482
1-3. Dorsal, side and ventral views.
4, 5. Dorsal and side views.
6. Surface showing ornamentation, × 8.
Rochester formation, Rose Hill, Md.

FIGS. 7, 8. OXYDISCUS COMPRESSUS Prouty 483
Side and dorsal views.
Rochester formation, east of Tonoloway, Md.

FIGS. 9, 10. BELLEROPHON MARYLANDICUM Prouty 483
Side and dorsal view.
Rochester formation, 2 miles southwest of Flintstone and 1 mile south of National Road, Md.

FIGS. 11-15. HORMATOMA ROWEI Swartz 483
11. View of type.
12. Portion showing external ornamentation, × 2.
13. Lower portion of shell showing ornamentation and columella, × 2.
14. Internal cast.
15. Columella, × 2.
Tonoloway formation, Pinto, Md.

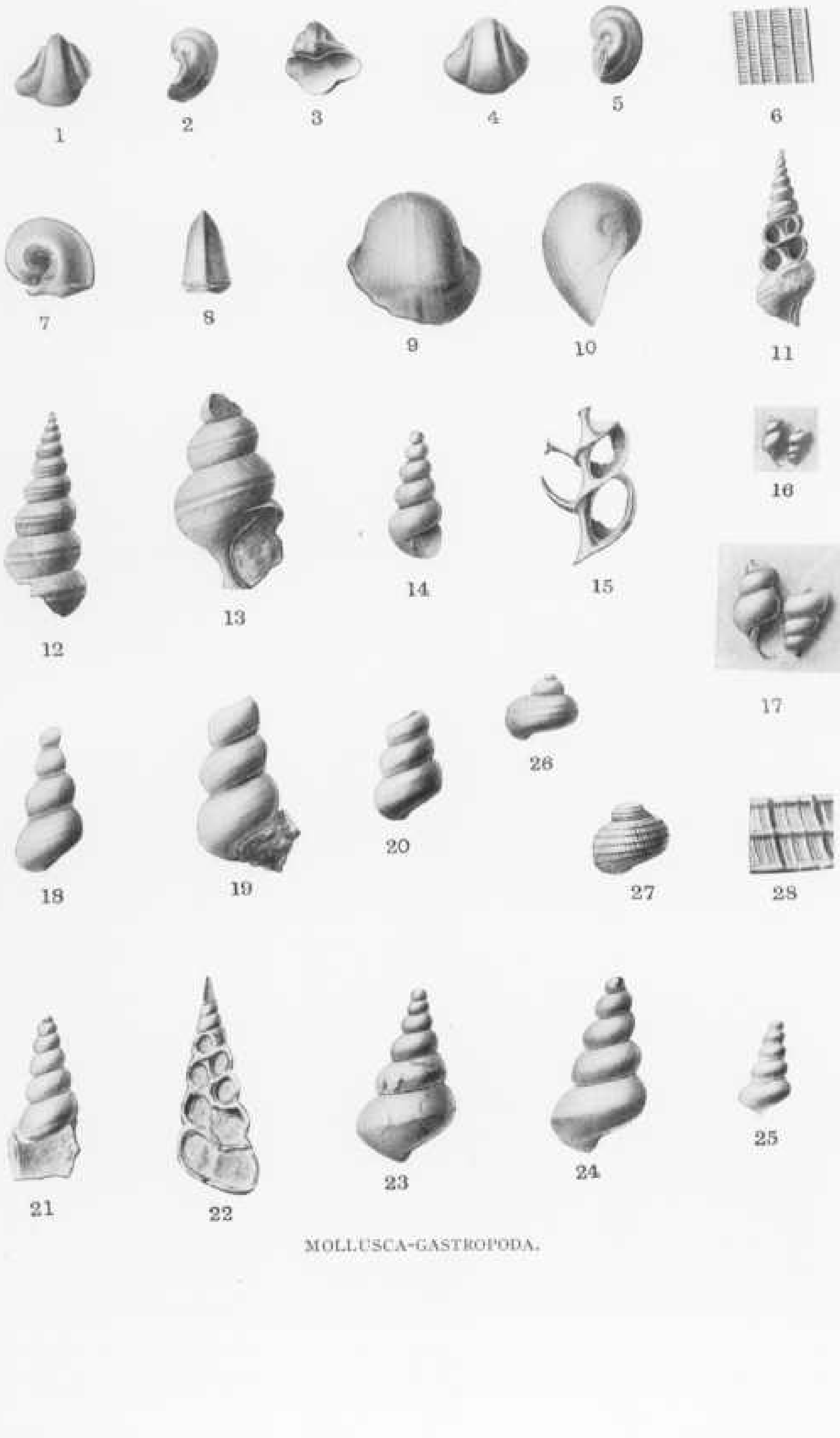
FIGS. 16-20. HORMATOMA ROWEI var. NANA Swartz 484
16. Internal casts of two shells.
17. Same, × 2.
18. Internal cast of type.
Tonoloway formation Keyser-Heddenville Road, Keyser, W. Va.
19. Internal cast.
Tonoloway formation, Grasshopper Run, W. Va.
20. Internal cast.
Tonoloway formation, Pinto, Md.

FIGS. 21, 22. HORMATOMA MARYLANDICA Prouty 485
21. Internal cast.
McKenzie formation, Cedar Cliff, Md.
22. Section showing columella.
McKenzie formation, Six-mile House, Section A.

FIGS. 23-25. HORMATOMA HOPKINSI Prouty 485
23. Shell showing traces of ornamentation.
24. Internal cast.
25. Small internal cast.
McKenzie formation, Cedar Cliff, Md.

FIG. 26. POLEUMITA MCKENZICA Prouty 487
Internal cast of type.
McKenzie formation, Cedar Cliff, Md.

FIGS. 27, 28. POLEUMITA TRANSVERSA Prouty 487
27. Dorsal view.
28. Portion of surface, × 4.
Rochester formation, Rose Hill, Md.



MOLLUSCA-GASTROPODA.

PLATE XXX

PAGE

FIGS 1, 2. SOLENOSPIRA MINUTA Hall (?) 486
1. Internal cast.
2. Same, × 2.
Tonoloway formation, National Road on Martin Mt., Md.

FIGS. 3-5. HOLOPEA FLINTSTONENSIS Swartz 486
3. Internal cast.
4. Same, × 2.
5. Internal cast doubtfully referred to this species.
Tonoloway formation, National Road on Martin Mt., Md.

FIG. 6. ORTHONYCHIA CLARKI Prouty 488
Side view, × 2.
Rochester formation, Rose Hill, Md.

FIGS. 7, 8. PLATYCERAS PAUCISPIRALE Prouty 489
7. Side view of specimen showing minutely coiled apex.
8. Side view of specimen showing shallow plication.
Rochester formation, Rose Hill, Md.

FIGS. 9, 10. PLATYCERAS NIAGARENSE (Hall) 489
9. Side view of shell preserving apical coil.
Rochester formation, Six-Mile House, Section A.
10. Side view of partially exfoliated shell.
Rochester formation, Rose Hill, Md.

FIG. 11. LOXONEMA ? sp. 488
Internal cast.
Tonoloway formation, Pinto, Md.

FIGS. 12-15. DIAPHOROSTOMA NIAGARENSE Hall 490
12. Dorsal view of young shell.
13. Dorsal view of large shell.
Rochester formation, Six-Mile House, Md., Section A.
14. Dorsal view of young shell.
15. Portion of surface of same showing ornamentation, × 10.
Rochester formation, Cumberland, Md.

FIG. 16. STYLIOLA sp. 490
Crushed shell.
Rochester formation, Cumberland, Md.

FIGS. 17, 18. COLEOLUS INTERSTRIATUS Hall 491
Fragmentary specimens.
Rose Hill formation, Cumberland, Md.

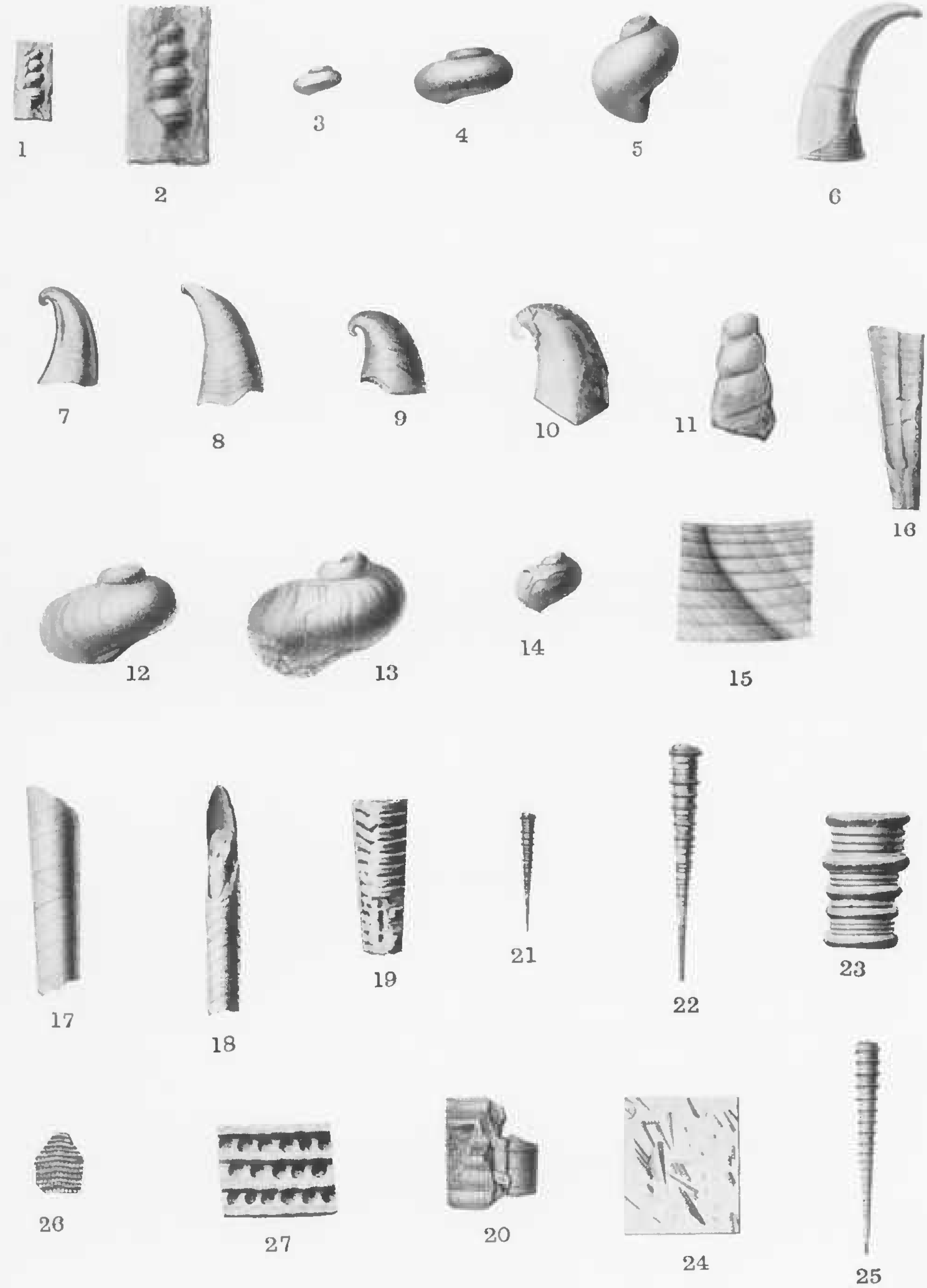
FIG. 19. ORTHOCERAS sp. 496
Internal cast of apical portion showing air chambers
Tonoloway formation, Quarry of Standard Lime and Stone Co., Keyser, W. Va.

FIG. 20. ORTHOCERAS sp. 496
Fragment of internal cast of air chambers.
McKenzie formation, Round Top, Md.

FIGS. 21-23. TENTACULITES GYRACANTHUS var. MARYLANDICUS Swartz 493
21. Shell showing ornamentation.
22. Same, × 2.
23. Portion of same showing ornamentation, × 10.
Tonoloway formation, Pinto, Md.

FIGS. 24, 25. TENTACULITES MINUTUS Hall 491
24. Cluster of shells.
25. Shell, × 5.
Rose Hill formation, Cumberland, Md.

FIGS. 26, 27. CONULARIA NIAGARENSIS Hall 494
26. Fragment of shell.
27. Part of surface, × 6.
Rochester formation, Rose Hill, Md.



MOLLUSCA-GASTROPODA AND PTEROPODA.

PLATE XXXI

	PAGE
FIGS. 1-4. TENTACULITES NIAGARENSIS Hall var. CUMBERLANDIÆ Hall.....	492

1. Shell partially exfoliated, × 7.
   Rochester formation, Pinto, Md.

2, 3. Shells preserving portions of ornamentation, × 10.

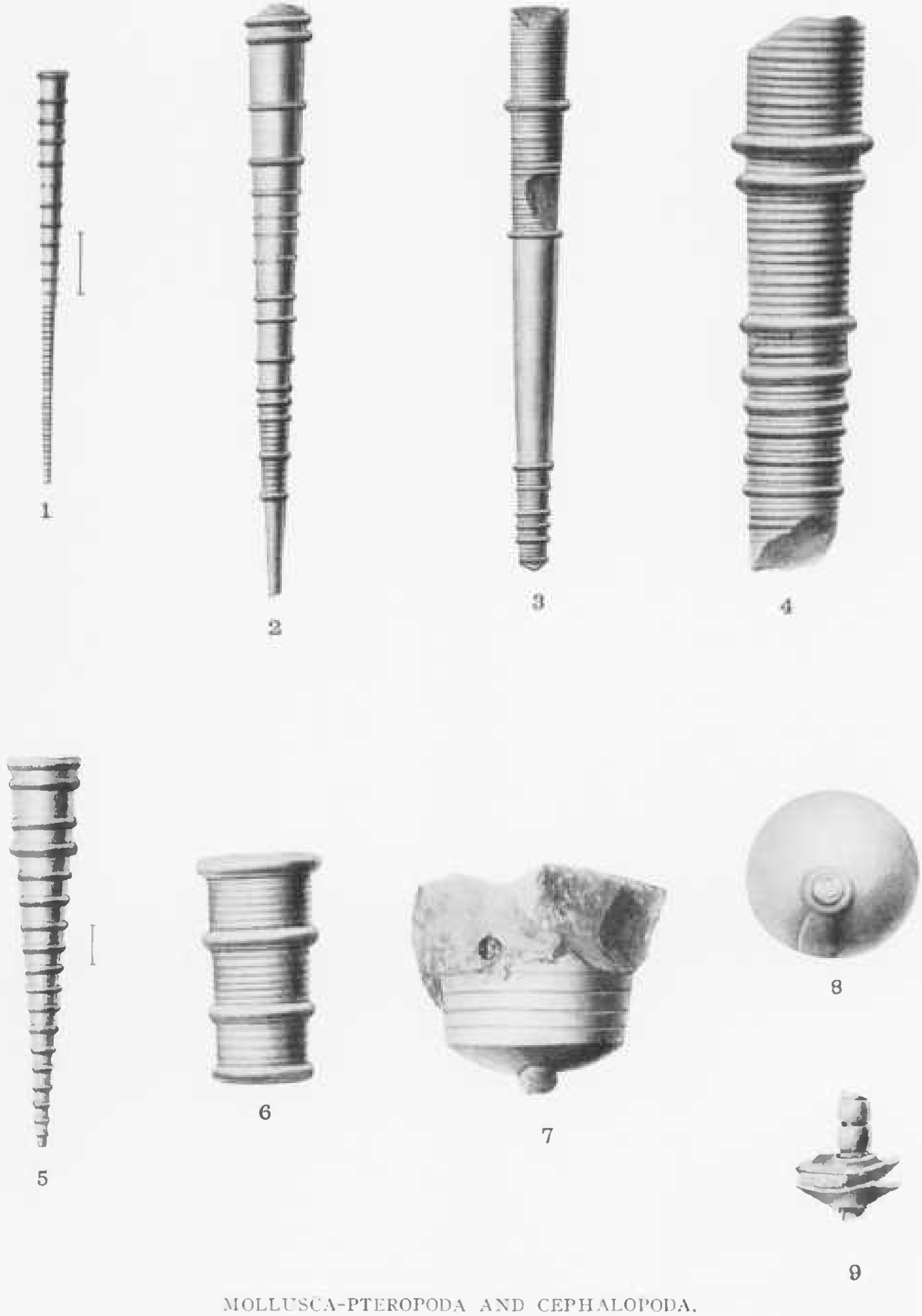
4. Part of shell enlarged to show ornamentation, × 20.
   McKenzie formation, Flintstone Creek, Md.

FIGS. 5, 6. TENTACULITES NIAGARENSIS Hall........................... 492

5. Exfoliated shell, × 10.
6. Portion of shell showing ornamentation, × 20.
   Rochester formation, Pinto, Md.

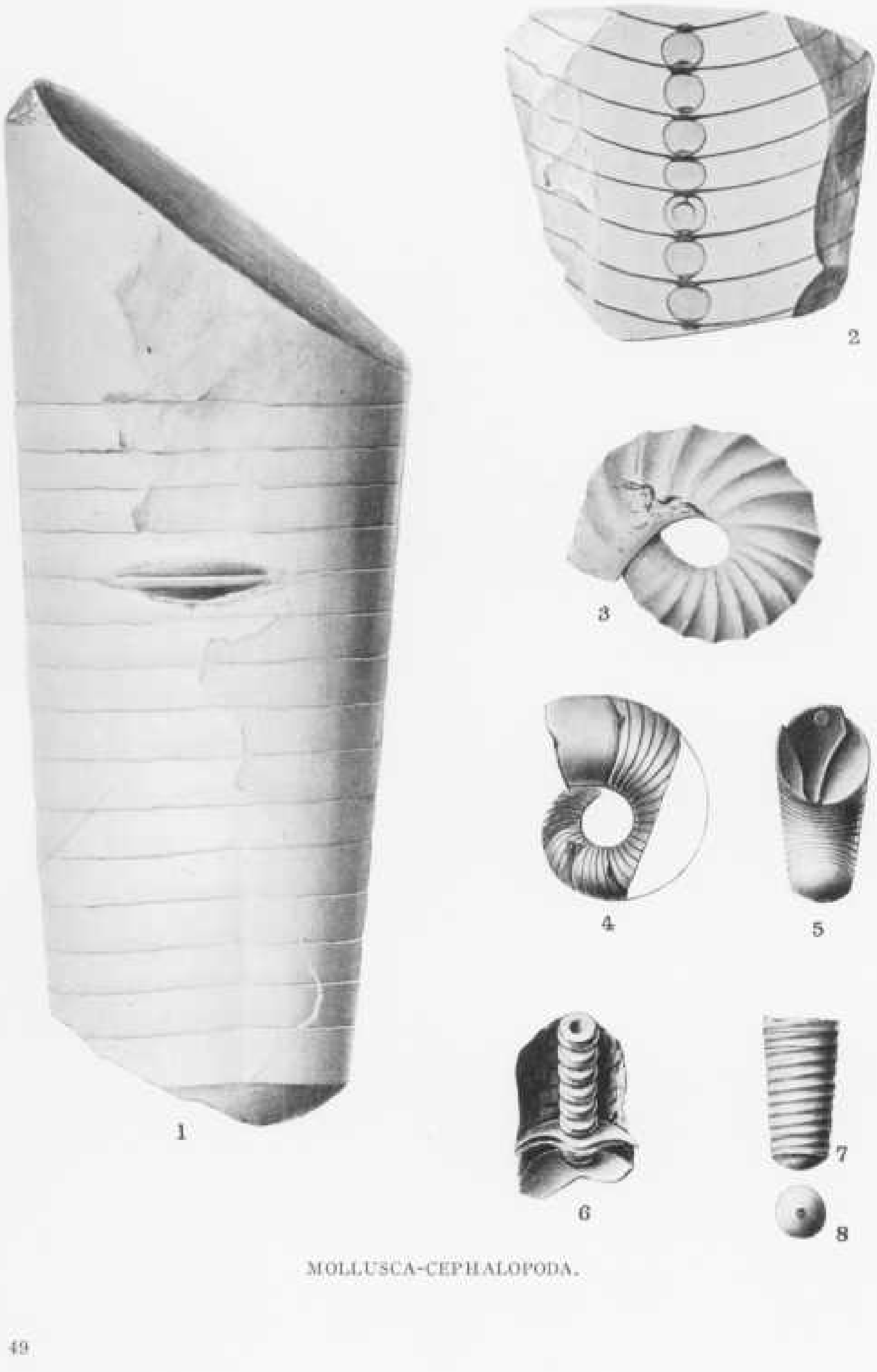
FIGS. 7-9. ORTHOCERAS BASSLERI Prouty............................... 495

7. Fragment showing 5 air chambers.
8. Same, showing septum and siphuncle.
9. Part of siphuncle.
   Rose Hill formation, Pinto, Md.



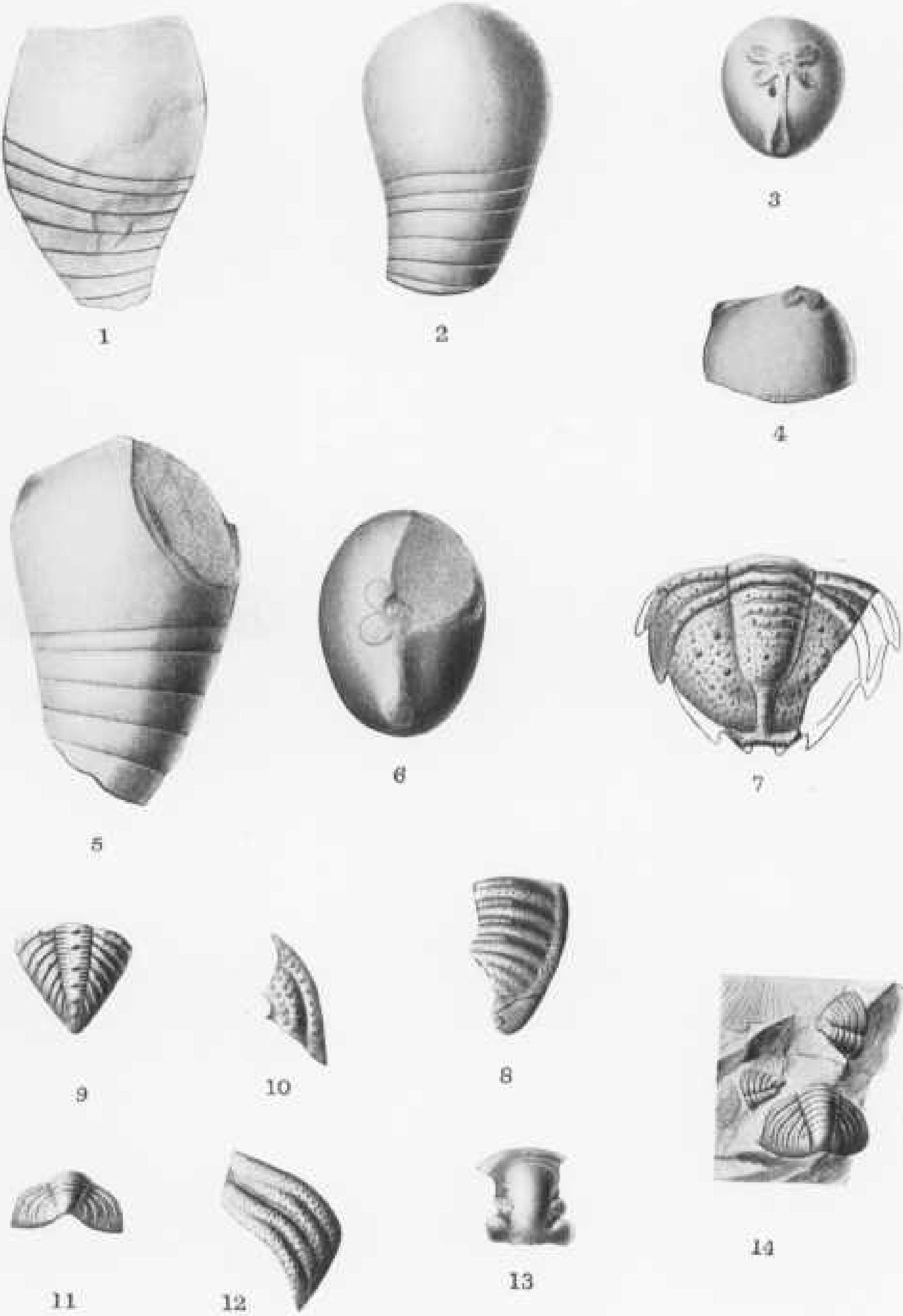
MOLLUSCA-PTEROPODA AND CEPHALOPODA.

PLATE XXXII



MOLLUSCA-CEPHALOPODA.

PLATE XXXIII



CEPHALOPODA, TRILOBITA.

PLATE XXXIV

PAGE

FIGS. 1-4. LIOCALYMENE CLINTONI (Vanuxem) 706

1. Small, nearly perfect individual.
2. Cephalon from in front.
3. Small pygidium.
4. Fragment of an average sized individual.

Rose Hill formation, Cresaptown, Md.

FIGS. 5-9. CALYMENE NIAGARENSIS Hall var. RESTRICTA Prouty 708

5. Glabella of small individual.

McKenzie formation, Flintstone Creek, Md.

6. Glabella.
7. Glabella and left cheek of large individual.
8. Pygidium.
9. Pygidium of large individual.

McKenzie formation, Grasshopper Run, W. Va.

FIGS. 10-13, 18. CALYMENE MACROCEPHALA Prouty 708

10-13. Cranidia.

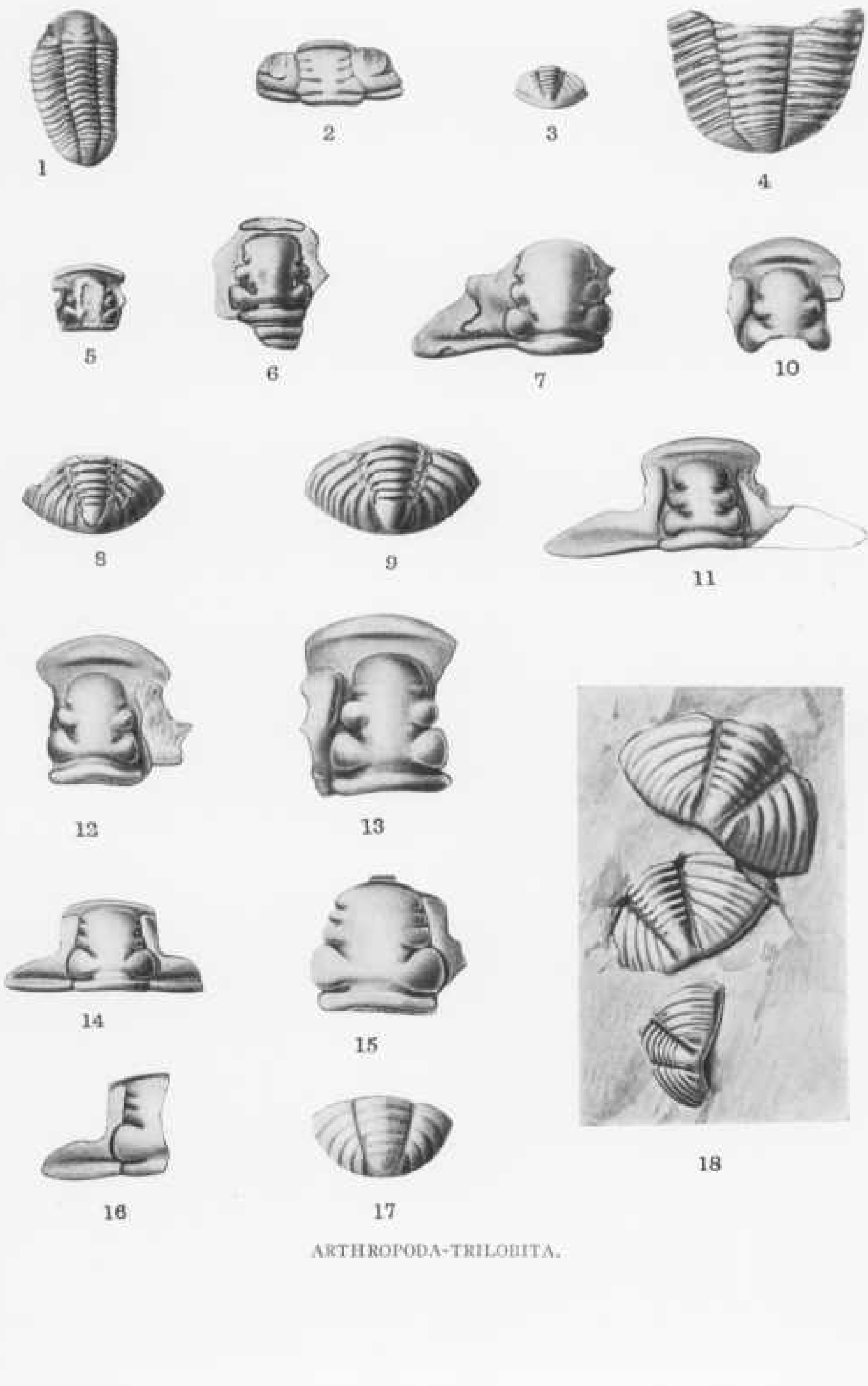
18. Pygidium.

Rose Hill formation, north of Cresaptown, Md.

FIGS. 14-17. CALYMENE CRESAPENSIS Prouty 710

14. Cranidium.
15. Glabella of large individual.
16. Glabella and part of left cheek.
17. Pygidium.

Rose Hill formation, north of Cresaptown, Md.



ARTHROPODA-TRILOBITA.

PLATE XXXV

PAGE

FIGS. 1-3. CALYMENE CAMERATA Conrad 711

1. Exfoliated glabella and parts of fixed cheeks.
   Tonoloway formation, Quarry of Standard Lime and Stone Co., Keyser, W. Va.
2. Glabella and part of fixed cheeks showing ornamentation.
3. Pygidium, $\times$ 2.
   Wills Creek formation, Flintstone Creek, Md.

FIG. 4. CALYMENE sp. ....Not described in text

Fragment of thoracic segments (from squeeze).
Tonoloway formation, Quarry of Standard Lime and Stone Co., Keyser, W. Va.

FIGS. 5-10. HOMALONOTUS DELPHINOCEPHALUS (Green) 712

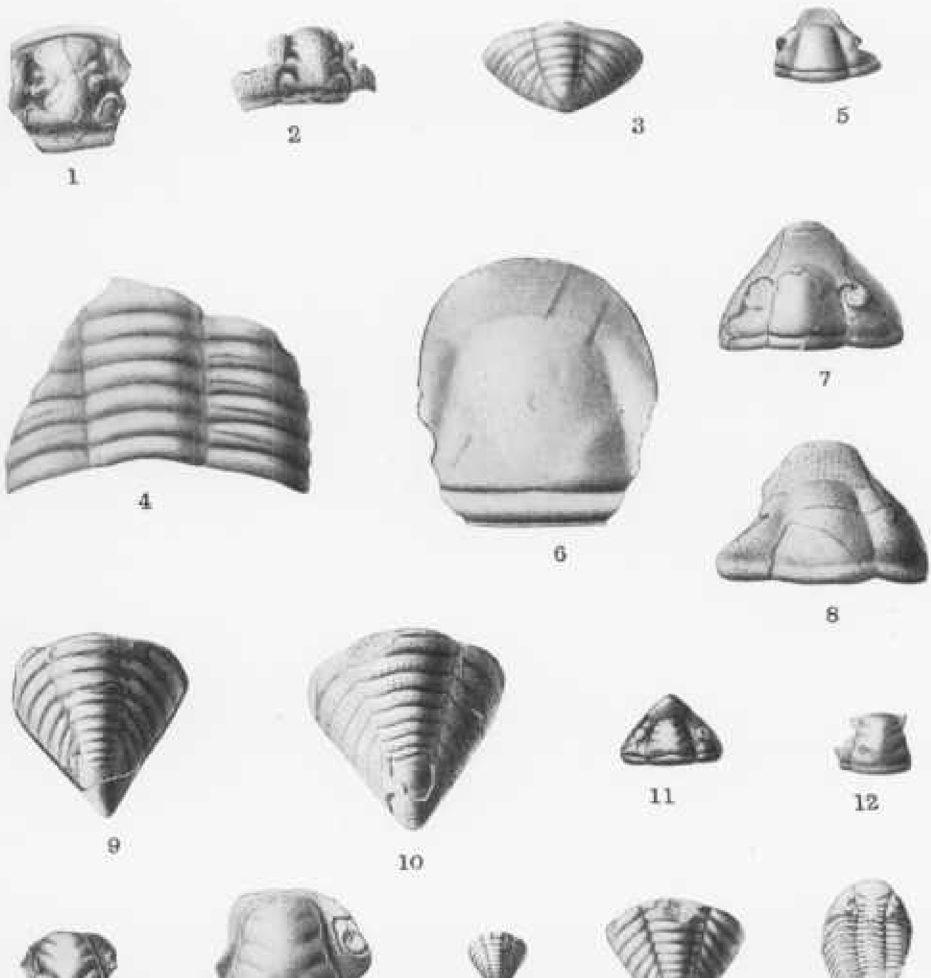
5. Small glabella.
6. Glabella of very large individual.
   Rochester formation, Cumberland, Md. Fig. 6 is from the Keefer sandstone.
7. Glabella.
   Rochester formation, Flintstone Creek, Md.
8. Glabella.
   Rochester formation, Six-Mile House, Md., Section A.
9. Exfoliated pygidium.
10. Pygidium showing surface ornamentation.
    Rochester formation, Rose Hill, Md.

FIGS. 11-16. HOMALONOTUS LOBATUS Prouty 714

11. Complete cephalon.
    Rochester formation, Flintstone Creek, Md.
12. Small glabella.
    Rochester formation, Six-Mile House, Md., Section A.
13. Small glabella.
14. Large glabella.
15. Small pygidium.
    Rochester formation, Six-Mile House, Md., Section B.
16. Large pygidium.
    Rochester formation, Rose Hill, Md.

FIGS. 17-21. DALMANITES LIMULURUS (Green) 714

17. Small complete individual.
    Rochester formation, Six-Mile House, Md., Section A.
18. Small cephalon.
19. Two cephalons of usual size.
20. Small pygidium.
    Rochester formation, Cumberland, Md.
21. Pygidium of large individual.
    Rochester formation, Rose Hill, Md.



ARTHROPODA-TRILOBITA.

PLATE XXXVI

PAGE

FIGS. 1, 2. LEPERDITIA ELONGATA Weller 500
The type specimen, a right valve, natural size and × 2.
Helderbergian ("Rondout"). Two miles south of Tristates, N. Y.

FIGS. 3-6. LEPERDITIA ELONGATA WILLSENSIS n. var 500
3. Right valve, × 2.
4. Left valve, × 2.
Wills Creek formation (172 feet above base), Cedar Bluff, Md.
5. Left valve, × 3.
Wills Creek formation (235 feet above base), Cumberland, Md.
6. Surface of slab, × 2, showing abundance of this variety.
Wills Creek formation (48 feet above base), Pinto, Md.

FIGS. 7, 8. LEPERDITIA MATHEWSI n. sp 500
The type specimens, right and left valves, × 6, showing the well-defined border on each valve.
Tonoloway formation (Basal part), Grasshopper Run near Hancock, Md.

FIGS. 9, 10. LEPERDITIA ALTOIDES Weller 501
One of the original types, nat. size and × 2.
Helderbergian ("Rondout"). Flatbrookville, N. J.

FIG. 11. LEPERDITIA ALTOIDES MARYLANDICA n. var 501
The type specimen, a right valve, × 3.
Wills Creek formation (182 feet above base), Flintstone, Md.

FIGS. 12, 13. LEPERDITIA SCALARIS PRÆCEDENS n. var 501
Two left valves, × 6.
Tonoloway formation (lower part), Keyser, W. Va., and Pinto, Md.

FIGS. 14-17. LEPERDITIA ALTA (Conrad) 502
14, 15. Two right valves, × 3.
16. A left valve, × 3, preserving the eye-spot.
Manlius limestone, Schoharie, N. Y.
17. Left valve, × 3, showing eye-spot.
Wills Creek formation (163 feet above base). Flintstone, Md.

FIG. 18. LEPERDITIA ALTA CACAPONENSIS n. var 502
18. Right valve, type, × 3, upon which the variety is founded.
Upper Clinton (*Drepanellina clarki* zone) (4 feet above Keefer sandstone). 1½ miles east Great Cacapon, Md.

FIG. 19. LEPERDITIA ALTA BREVICULA n. var 502
Slab with two left valves, × 3.
Wills Creek formation, Pinto, Md.

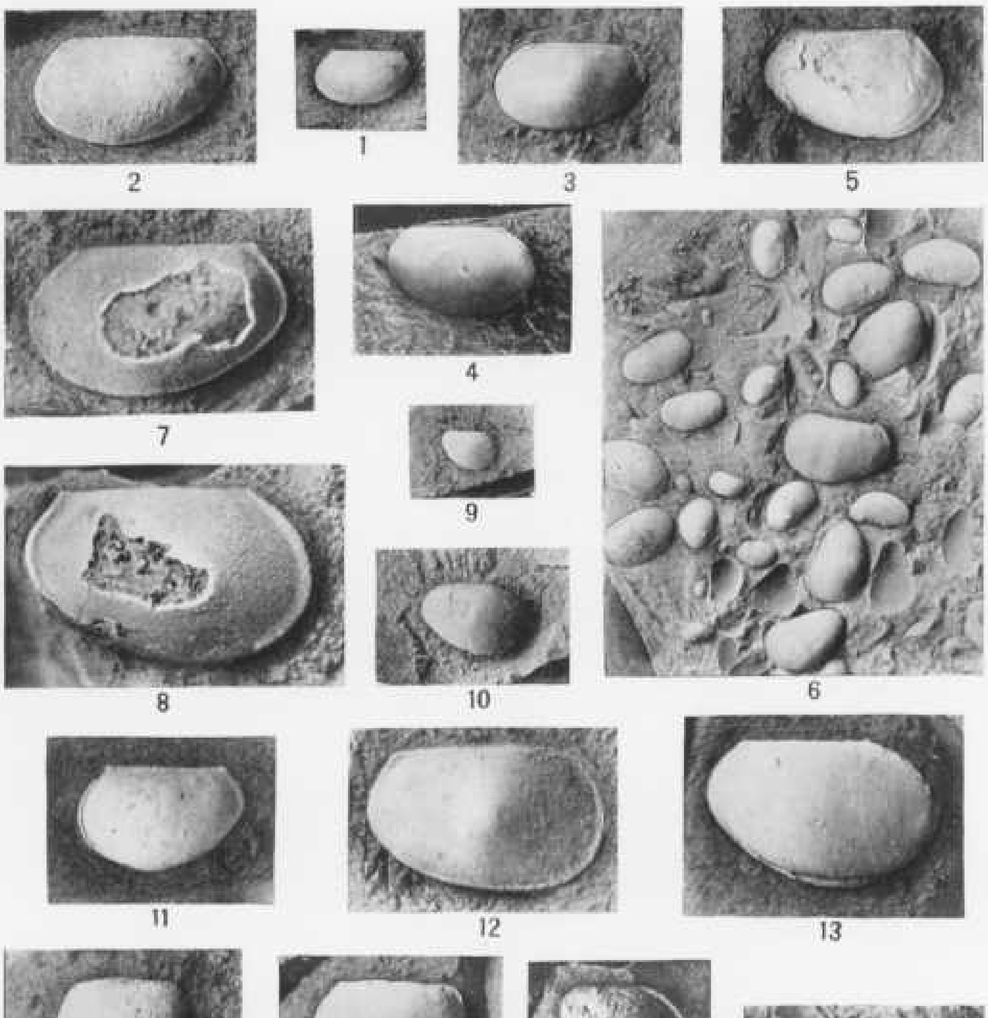
FIG. 20. APARCHITES VARIOLATUS n. sp 504
A valve of this curiously marked species, × 20.
Lower Clinton (57 feet above Tuscarora sandstone), Wills Creek, Cumberland, Md.

FIG. 21. APARCHITES (?) PUNCTILLOSA n. sp 503
The type specimen, a right valve, × 20.
Tonoloway formation (lower part), Keyser, W. Va.

FIG. 22. APARCHITES ALLEGHENIENSIS n. sp 504
A left valve, × 20.
Upper Clinton (*Drepanellina clarki* zone, 5 feet below top). Cumberland, Md.

FIG. 23. APARCHITES OBLIQUATUS n. sp 503
The type specimen, × 12. A right valve showing the central spot and the surface marking.
Tonoloway formation (near top). Keyser, W. Va.

FIG 24. ERIDOCONCHA ROTUNDA n. sp 504
View, × 20, of the specimen upon which this peculiar species is founded.
Upper Clinton (*Mastigobolbina typus zone*). Lakemont, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XXXVII

PAGE

FIGS. 1, 2. EUPRIMITIA BUTTSI n. sp. 505
1. Cast of a left valve, × 8.
2. Imperfect mold of a left valve, × 20, showing the well-developed furrow and surface reticulation.
Lower Clinton (*Zygobolba erecta* zone). 1½ miles southwest of Cherrytown, Pa.

FIG. 3. LACCOPRIMITIA RESSERI n. sp. 505
Cast of a right valve, × 20.
Upper Clinton (*Drepanellina clarki* zone 5 feet below top). Cumberland, Md.

FIGS. 4-6. CHILOBOLBINA BILLINGSI (Jones) 518
4, 5. Two male valves, × 12.
Clinton (probably middle) top of Dyer Bay dolomite. Clay Cliffs, 2 miles west of Cabot Head, Lake Huron, Ontario.
6. Cast interior, male valve, × 8.
Middle Clinton (*Mastigobolbina lata* zone). Cumberland, Md.

FIGS. 7-9. CHILOBOLBINA HARTFORDENSIS n. sp. 520
7. Female valve, × 12, showing brood pouch.
8. Cast of interior of valve, × 12, with most of frill broken away.
9. Natural cast in coarse grained sandstone, × 12, with frill preserved.
Middle Clinton (*Mastigobolbina lata* zone). New Hartford, N. Y.

FIGS. 10-12. CHILOBOLBINA PUNCTATA n. sp. 516
10. Right valve, male, × 12, with frill broken away.
11. Left valve, female, × 12.
12. Right valve, male, × 12, exhibiting punctate surface and frill.
Clinton (probably middle), top of Dyer Bay dolomite. Clay Cliffs, 2 miles west of Cabot Head, Lake Huron, Ontario.

FIGS. 13, 14. CHILOBOLBINA PUNCTATA BREVIS n. var. 518
13. Cast of interior male valve, × 6, preserving the frill.
14. Another example, × 6, with frill broken away.
Middle Clinton (*Mastigobolbina lata* zone). Wills Mountain near Cumberland, Md.

FIGS. 15, 16. APATOBOLBINA APPRESSA n. sp. 523
15, 16. Natural casts of left and right valves, × 8, with the frill broken away.
Top of Lower Clinton, top of ore seam, one-half mile northwest of Frankstown, Pa.

FIGS. 17-19. APATOBOLBINA GRANIFERA n. sp. 522
17, 18. Right valve, × 12 and × 8, with frill partially preserved.
19. Another male valve, × 12, preserving more of the frill.
Upper Clinton (near base of *Mastigobolbina typus* zone). 2 miles west of Hollidaysburg, Pa.

FIG. 20. HALLIELLA SUBAEQUATA n. sp. 514
The type specimen, a right valve, × 20, showing short hinge line, median furrow and surface ornament.
Wills Creek formation (45 feet above base). Pinto, Md.

FIG. 21. HALLIELLA (?) TRIPLICATA Ulrich and Bassler 515
A left valve, × 20.
Tonoloway formation (lower part). Keyser, W. Va.

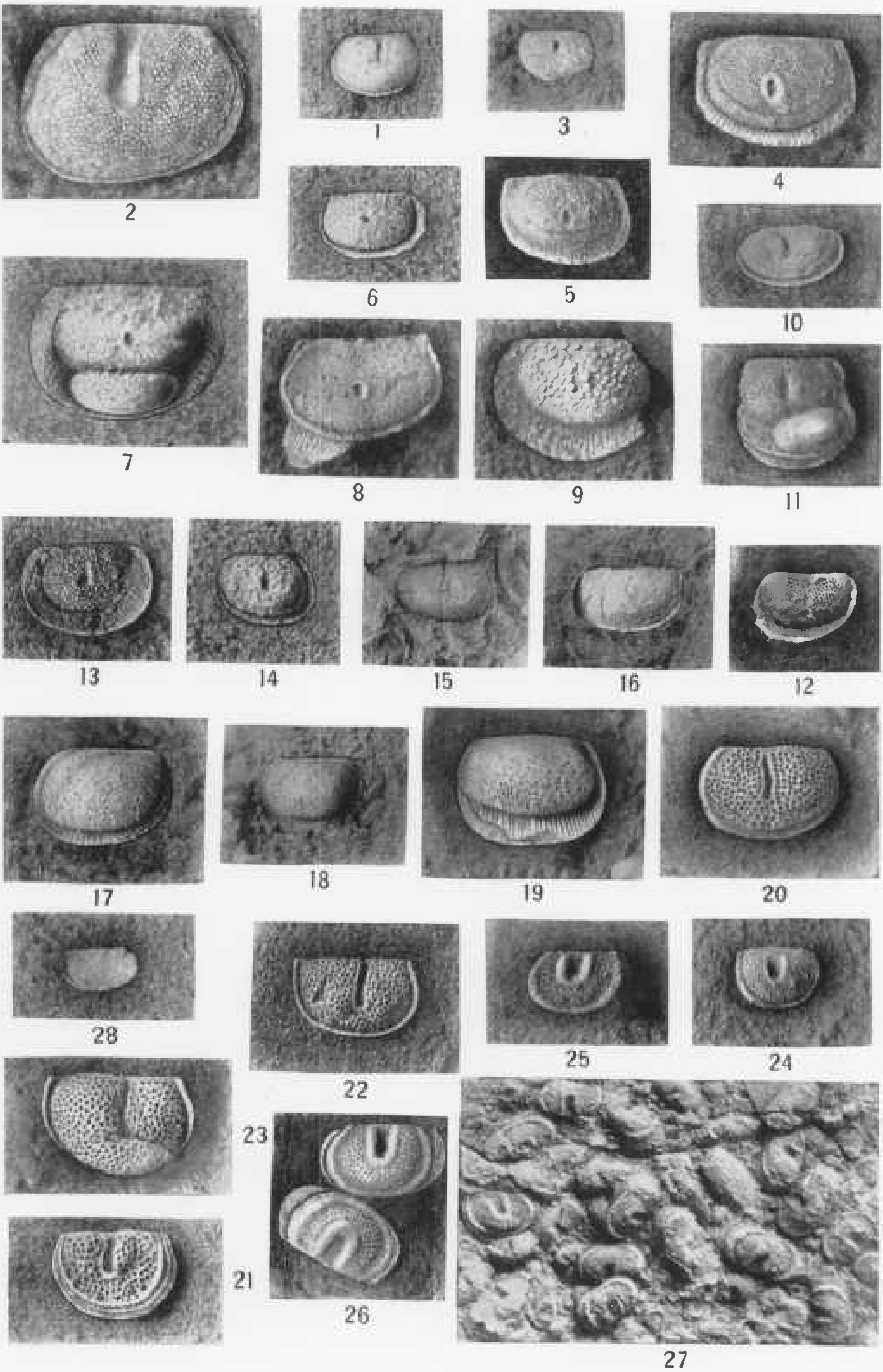
FIGS. 22, 23. HALLIELLA FISSURELLA n. sp. 514
22. Left valve male, × 20, exhibiting the narrow, fissure-like sulcus.
23. Left valve, female, × 20.
Tonoloway formation (upper part). Keyser, W. Va.

FIG. 24. BOLLIA IMMERSA n. sp. 513
The type specimen, a right valve, × 20, exhibiting the specific characters of the outer ridge at the exterior edge and the inner ridge failing to reach the dorsal edge.
Wills Creek formation (45 feet above base). Pinto, Md.

FIG. 25. BOLLIA NITIDA n. sp. 514
Right valve, × 20, showing the flat and obliquely outlined, minutely reticulated valve.
Wills Creek formation (45 feet above base). Pinto, Md.

FIGS. 26, 27. BOLLIA PULCHELLA n. sp. 513
26. Two valves, × 20, showing reticulated surface and the characteristic two ridges, the outer one developed within the exterior edge.
27. Surface of slab, × 12, exhibiting abundance of this ostracode.
Wills Creek formation (125 feet above base). Pinto, Md.

FIG. 28. PRIMITIELLA EQUILATERALIS n. sp. 505
Valve, × 20.
Upper Clinton (*Drepanellina clarki* zone) McKees farm, 7 miles west of Lewiston, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XXXVIII

PAGE

1, 2. Two right valves, × 20, showing the spine and pit and the characteristic form of the marginal ridge.

Upper Clinton (Rochester shale). Lockport, N. Y.

3. A large right valve, × 20.

Upper Clinton (*Drepanellina clarki* zone). McKees farm, 7 miles west of Lewiston, Pa.

A left valve, × 20, with spine restored in outline.

Upper Clinton (*Drepanellina clarki* zone). Cumberland, Md.

The type specimen, a right valve, × 20.

Tonoloway formation (upper part). Keyser, W. Va.

6. Right valve, × 20.
7. Right valve, × 20, tilted to show ventral edge and length of spine.
8. Exterior of large right valve, × 12, illustrating pit and base of spine.
9. Left valve, × 20.

Upper Clinton (*Drepanellina clarki* zone). Cumberland, Md.

10. Cast of interior of right valve, × 20.

Upper Clinton (*Drepanellina clarki* zone). McKees farm, 7 miles west of Lewiston, Pa.

A left valve, × 20, introduced for comparison. Figure poor because of uneven natural etching of the specimen.

Upper Clinton (Rochester shale). Lockport, N. Y.

12. Right valve, × 20, with apex of spine broken away.
13. Cast of interior, left valve, × 20, doubtfully referred to this species.

Upper Clinton (*Drepanellina clarki* zone). McKees farm, 7 miles west of Lewiston, Pa.

Right valve, × 20, with spine and pit well preserved.

Upper Clinton (*Mastigobolbina typus* zone). Hollidaysburg, Pa.

The type specimen, × 20, showing the marginal ridge, the ridge around the spine, which is broken, and the finely reticulated surface.

McKenzie formation (20 feet above base), one and one-half miles east of Great Cacapon, Md.

Three right valves, × 20, showing spine in various degrees of preservation, the pit posterior to it and the marginal ridge along the posterior half.

McKenzie formation (73 and 82 feet below top). Flintstone, Md.

The type specimen, × 12, a right valve distorted laterally by pressure, the normal outline indicated by dotted line.

Middle Clinton (*Zygobolbina emaciata* zone). Cove Gap, Tuscarora Mt., 4½ miles n. w. Mercersburg, Pa.

Right valve, × 20.

Upper Clinton (*Drepanellina clarki* zone). McKees farm, 7 miles west of Lewiston, Pa.

The type specimen, × 20, a right valve.

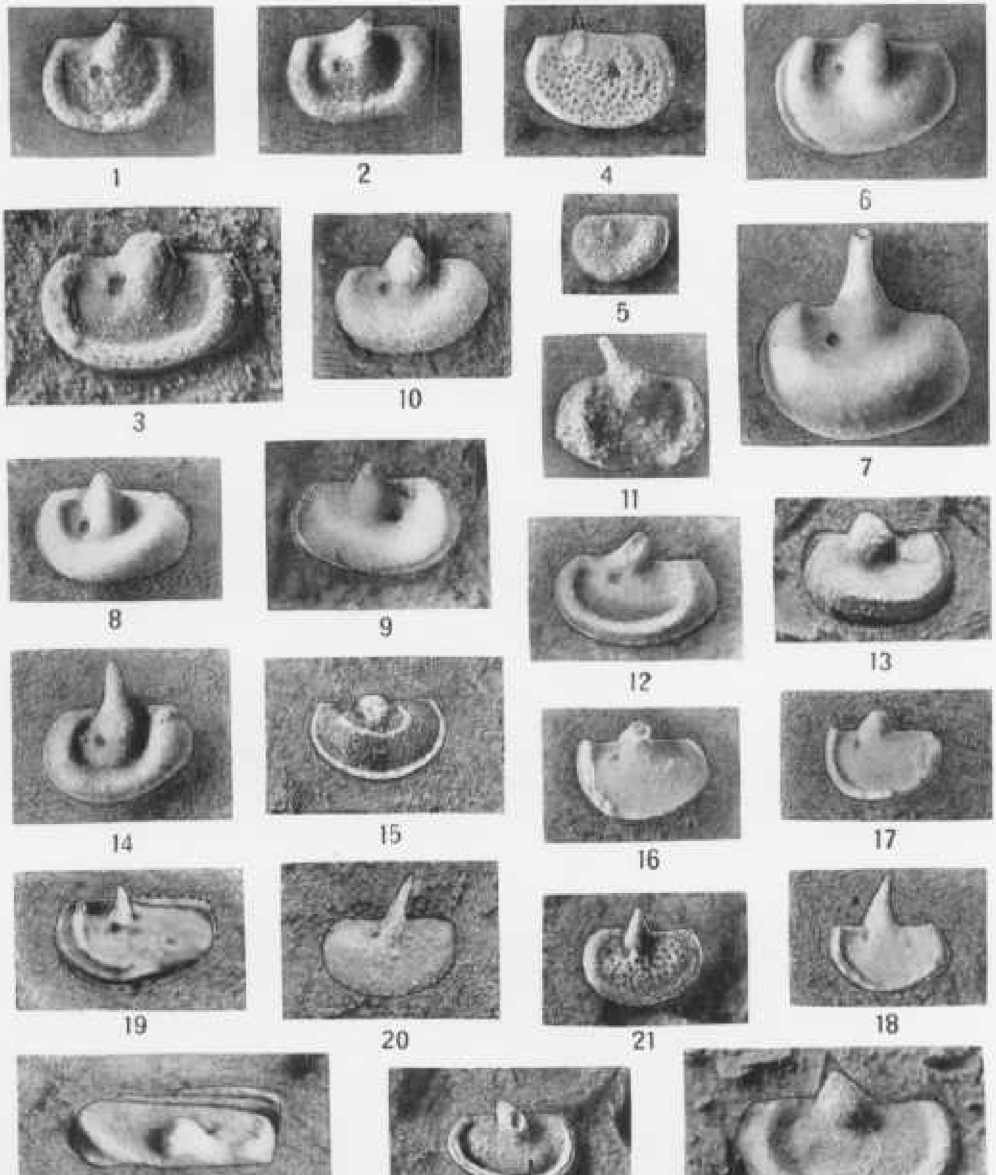
Upper Clinton (*Mastigobolbina typus* zone). Two miles west of Hollidaysburg, Pa.

The type specimen, × 20, a left valve showing the high marginal wall and decidedly unequal ends.

McKenzie formation (middle). Cumberland, Md.

23. Dorsal edge view of right valve, × 20, showing remains of the high crested ridge in the background.
24. Casts of interior of several valves, × 20.
25. Casts of interior of two left valves, × 20.
26. A large left valve, × 20, in which the marginal ridge is thicker than in the typical form. Probably more closely allied to *P. intermedia* (see fig. 12).

Upper Clinton (*Drepanellina clarki* zone). McKees farm, 7 miles west of Lewiston, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XXXIX

PAGE

FIGS. 1-4. ZYGOBOLBA ERECTA n. sp. 539

1. Gutta percha squeeze, right valve male, × 8.
2. Natural mold, exterior of left valve male, × 8.
3. Gutta percha squeeze of left valve female, × 12.
4. Right valve male, × 8.

Lower Clinton (*Zygobolba erecta* zone). East slope Tussey Mountain, 1½ miles southwest of Cherrytown, Pa.

FIGS. 5, 6. ZYGOBOLBA CARINIFERA n. sp. 540

5. Gutta percha squeeze, × 8, of right valve male.
6. Natural cast of interior of a left valve, × 8. The overhanging post ventral part of the border is incompletely indicated.

Lower Clinton (*Zygobolba erecta* zone). East slope Tussey Mountain, 1½ miles southwest Cherrytown, Pa.

FIGS. 7-9. ZYGOBOLBA REVERSA n. sp. 541

7. Gutta percha squeeze right valve male, × 8.
8. Natural mold exterior left valve, × 8.
9. Natural cast exterior left valve male, × 8.

Lower Clinton (*Zygobolba erecta* zone). East slope Tussey Mountain, 1½ miles southwest of Cherrytown, Pa.

FIGS. 10-14. ZYGOBOLBA ARCTA n. sp. 539

10. Gutta percha squeeze right valve male, × 8, selected as the holotype.
11. Right valve male, × 8.

Middle Clinton, Gap, Gate City, Va.

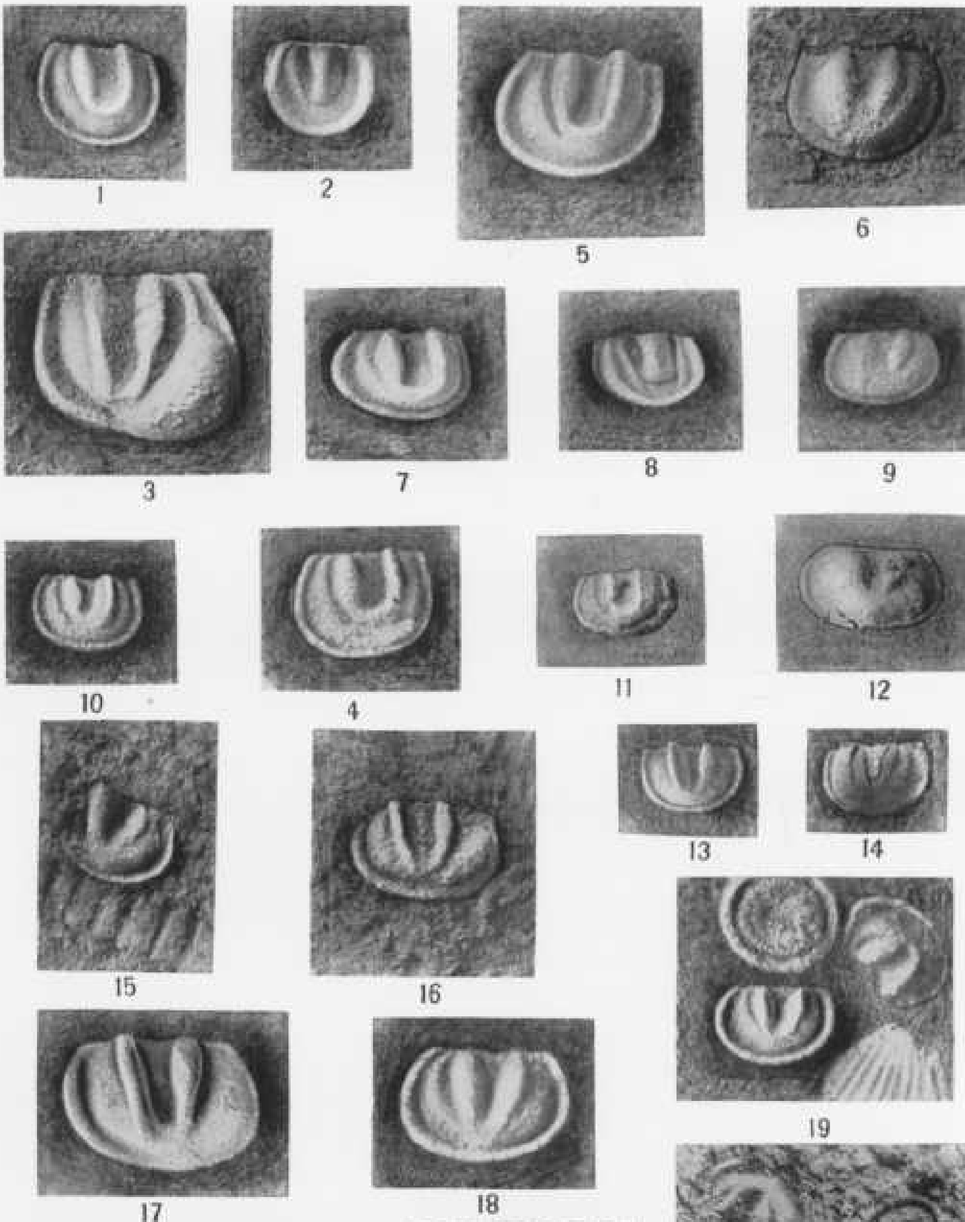
12. Natural cast interior left valve male, × 8.
13, 14. Two valves, male, × 8.

Middle Clinton, 50 feet beneath ore bed. 8 miles south of Big Stone Gap, Va.

FIGS. 15-22. ZYGOBOLBA DECORA (Billings) (see also Plate LXIV, figs. 21-25) 537

15. Gutta percha squeeze of imperfect left valve, male, × 8.
16 and 17. Gutta percha squeezes of two left valves, female, of a short variety with antero-dorsal angle more obtuse than usual, × 12.
18. Gutta percha squeeze of right valve, male, of same variety as figs. 16 and 17, × 12.
19. Right and left valves, males, of more nearly typical forms, × 8.
20. Gutta percha squeezes of three male valves, the middle and left specimens of typical form, the one on right side badly drawn and of doubtful relations, × 8.
21. Gutta percha squeeze of right valve, female, of same variety as figs. 16, 17 and 18.
22. Two right valves and incomplete impressions of others, all males, × 8, of fairly typical examples.

Middle Clinton, Gap, Gate City, Virginia.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XL

PAGE

FIGS. 1-10. ZYGOBOLBA BIMURALIS n. sp. 555

1. Gutta percha squeeze, slab with male valves, × 8, variously tilted so as to give varying outlines in the photographs.
2. Typical male, right valve, × 8.
3. Gutta percha squeeze, exterior right valve, large female, × 8, associated with typical specimens of the species but probably distinct. It suggests a variety of *Z. decora* figured on plate xxxix.
4. One male, right, and two female, left and right valves, × 8.
5. Slab with three female valves and one male, × 8.
6. Uncommonly small left female valve, × 8. The anterior extremity of the pouch also is more acuminate and prominent than usual.
7. Left male valve, × 8.
8. Slab with two male valves and one right and one left female valve, × 8.
9. Gutta percha squeeze, left valve, female, × 8.
10. Sandstone slab, natural size, with numerous valves.

Middle Clinton, 173 feet above Tuscarora sandstone. Cumberland, Md.

FIGS. 11-14. ZYGOBOLBA DECORA (Billings) (see also plate xxxix, figs. 15-22, and plate lxiv, figs. 21-25) 537

11. Three male and one female valve, × 8.
12. Valves, natural size.

13, 14. Left valves, female, and with the former, two young males, × 8.

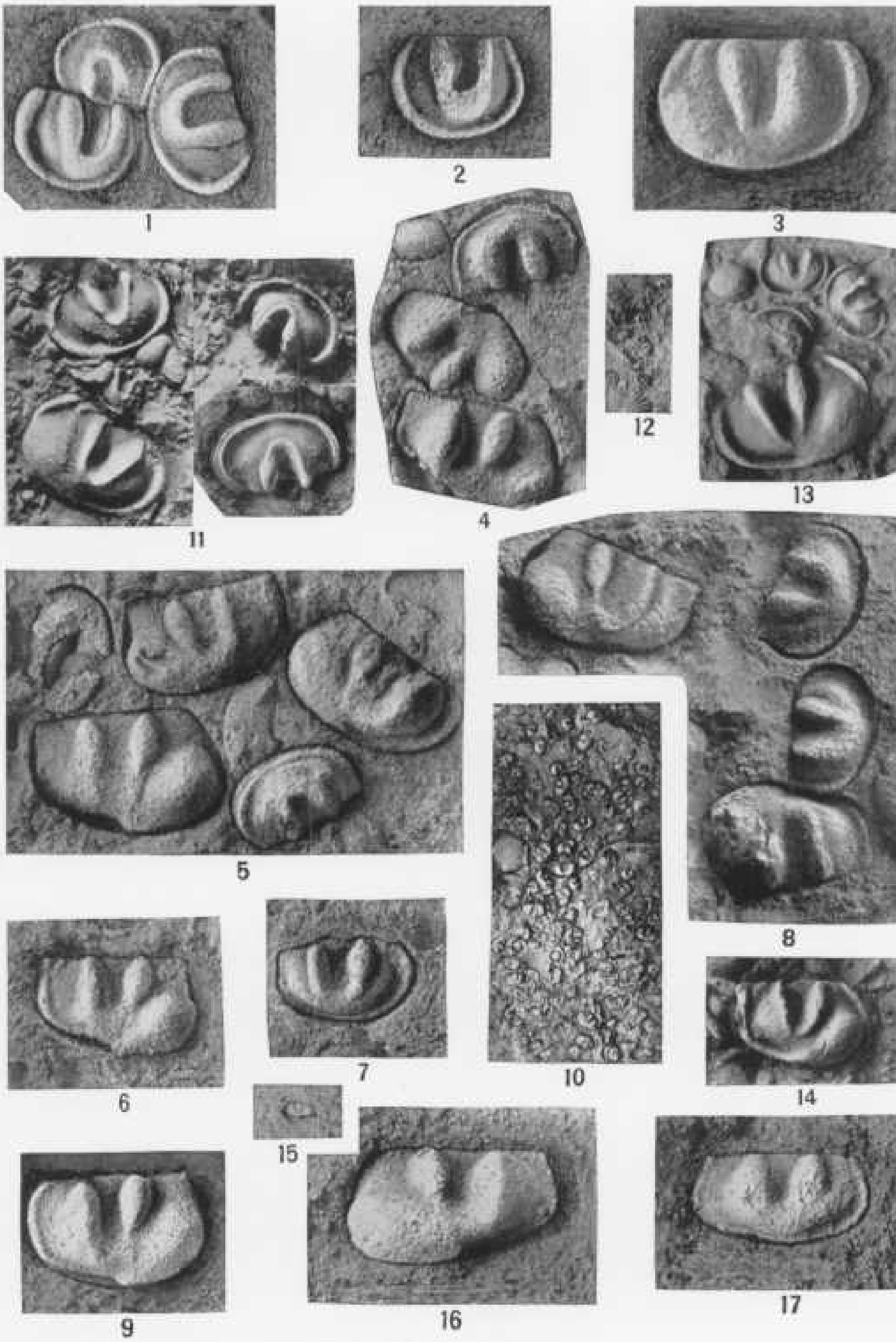
Jupiter River formation, Island of Anticosti.

FIGS. 15-17. ZYGOBOLBA ELONGATA n. sp. 542

15, 16. Natural casts, female right valves, natural size and × 8.

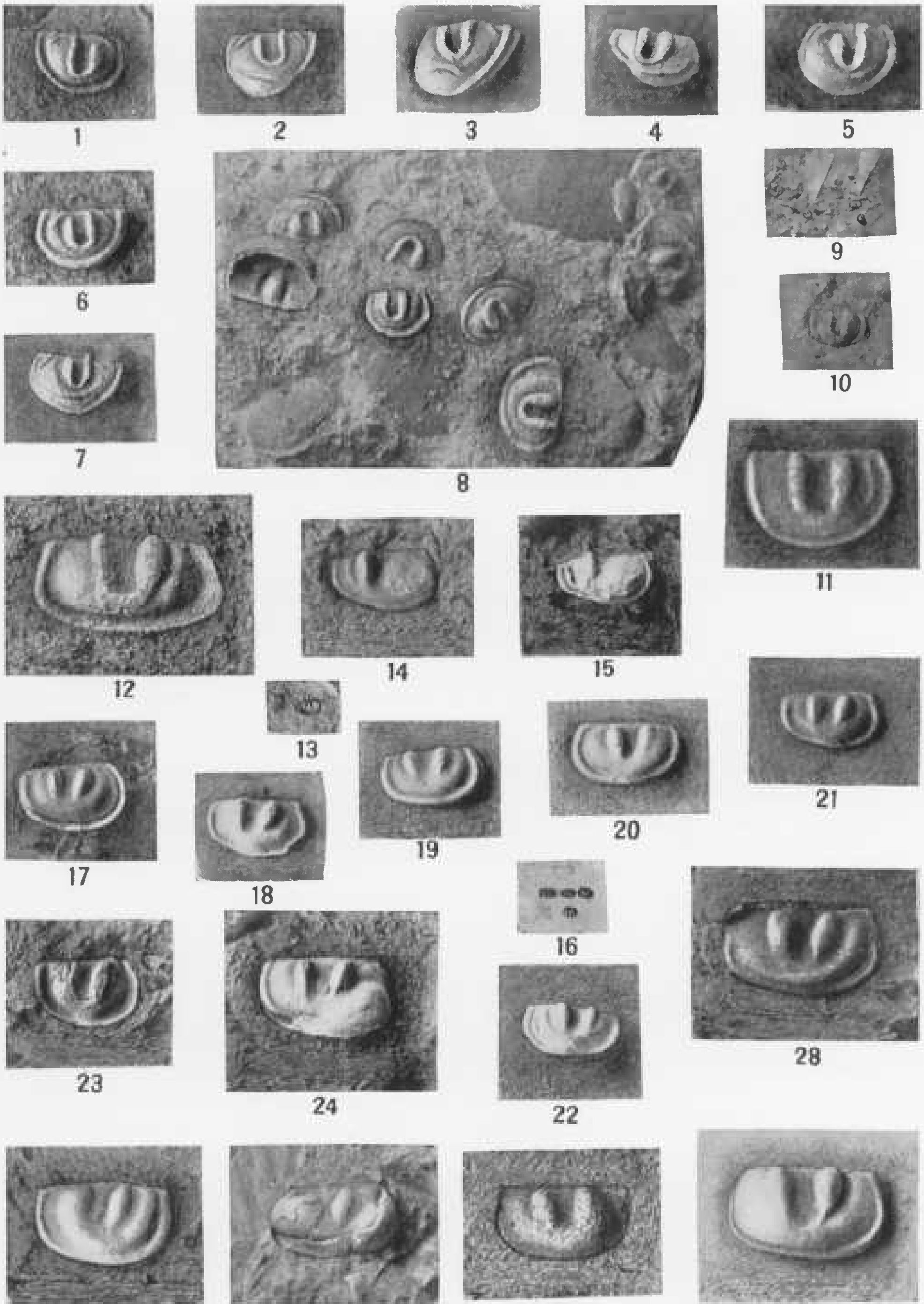
17. Natural cast, male left valve, × 8.

Lower Clinton (*Zygobolba erecta* zone). East slope Tussey Mountain, 1½ miles southwest of Cherrytown, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLI



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLII

PAGE

FIG. 1. ZYGOBOLBINA CONRADI LATIMARGINATA n. var. (see also Plate XLIII, Figs. 12-19) 565

Gutta percha squeeze of 3 female valves, two right and one left, × 8.

Middle Clinton (*Mastigobolbina lata* zone), 300-325 feet above Tuscarora sandstone, ¾ mile south of Reedsville, Pa.

FIGS. 2-10. ZYGOBOLBINA EMACIATA n. sp 567

2. Gutta percha squeeze of exterior, left valve, female, × 8.

   Lower part of Middle Clinton, Gate City, Va.

3. Left valve, male, distorted (reduced in height), × 8.

4-6. Three right valves, female, × 6, showing varying aspects due to distortion.

7. Male left valve, × 8, shortened by pressure. The normal form may be imagined as a composite of this and fig. 3.

8. Female left valve, × 6, distorted, doubtfully referred to this species.

9, 10. Surface of slab, natural size and × 3, illustrating abundance of examples.

   Lower part of Middle Clinton (*Zygobolbina emaciata* zone). Near toll-gate, Cove Gap, Tuscarora Mountain, 4½ miles n. w. Mercersburg, Pa.

FIGS. 11-20. ZYGOBOLBINA CARINATA n. sp 566

11-12. Two casts of the interior of left valves, male, × 8.

13. Similar cast of young male left valve, × 8, showing impression of flange.

14. Left valve, male, × 8.

15, 16. Two right valves, exterior, male, × 8.

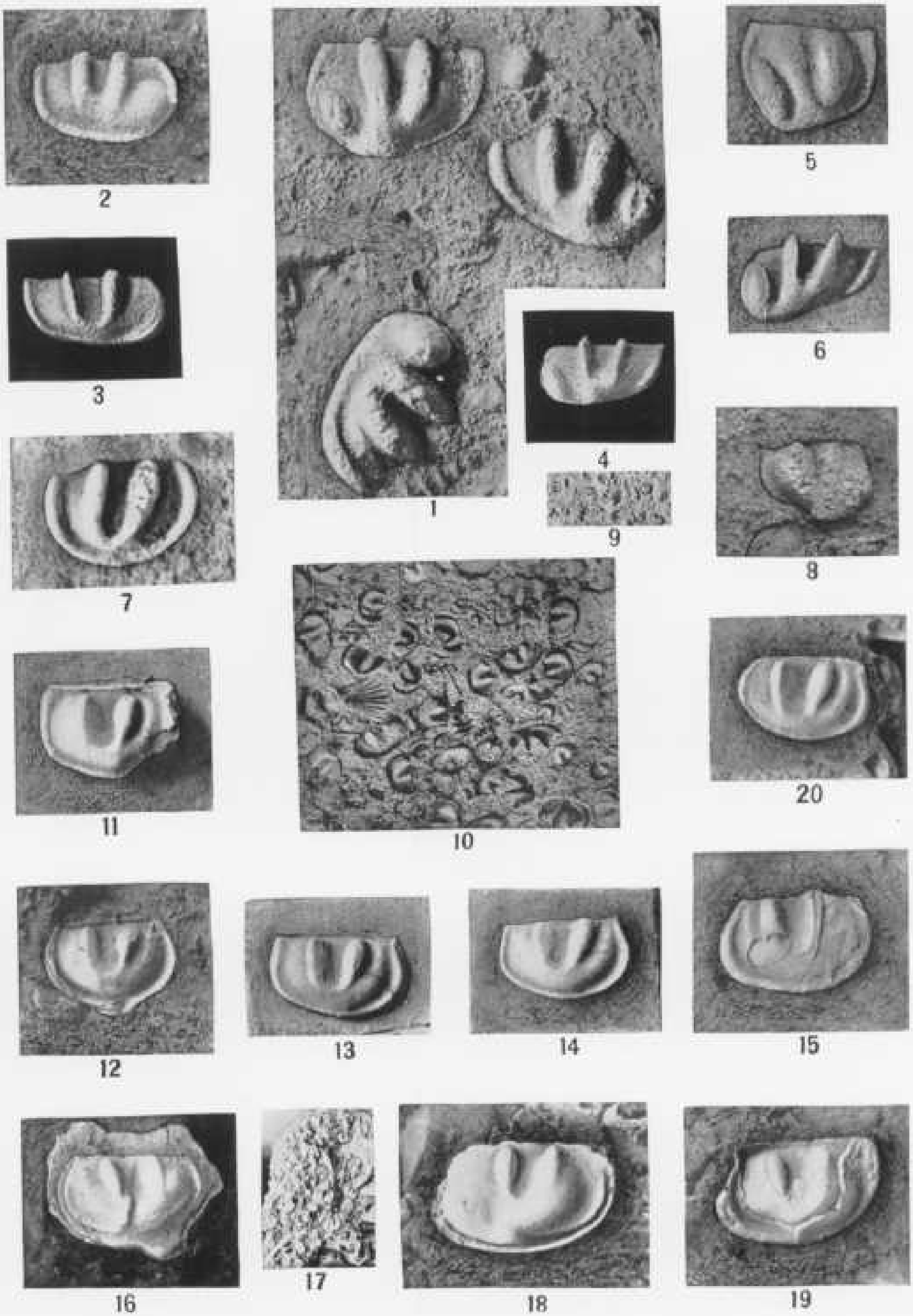
17. Surface of slab with examples, × 1.

18. Cast interior, female, right valve, × 8.

19. Partial cast of the interior, male, right valve, × 8, but retaining shell of flange.

20. Left valve, male, × 8, cast of interior.

   Top of Lower Clinton. Eight feet above main seam of Frankstown ore bed, 1 mile northwest of Frankstown, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLIII

PAGE

FIGS. 1-11. ZYGOBOLBINA CONRADI n. sp. 564

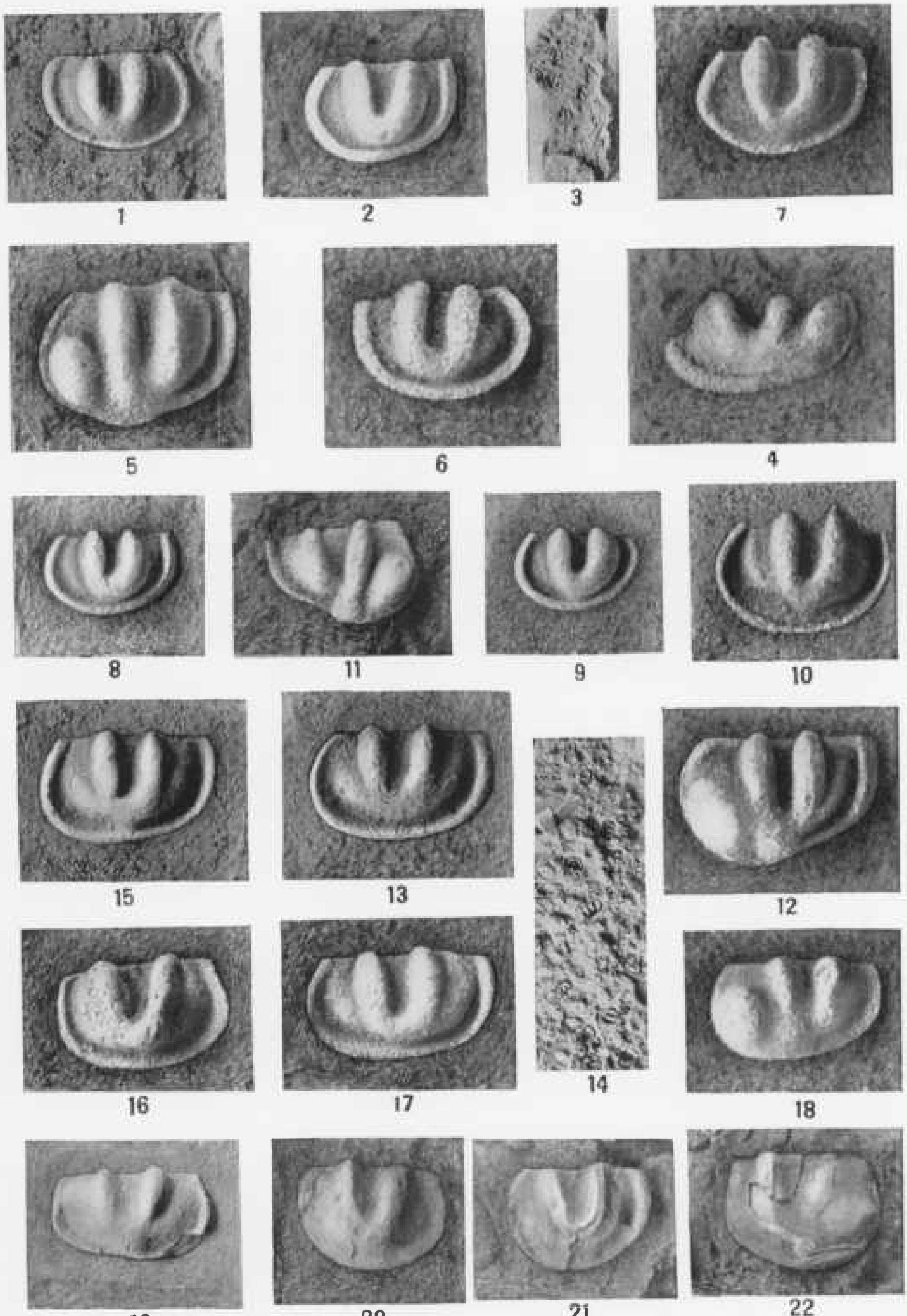
1. Gutta percha squeeze, left valve, male, × 8.
2. Squeeze of right valve, male, × 8.
   Middle Clinton (*Mastigobolbina lata* zone), New Hartford, N. Y.
3. Sandstone fragment with molds, natural size.
4. Half ventral view of left valve, female, × 8.
5. Right valve, female, × 8.
6. Right valve, male, × 8.
7. Gutta percha squeeze of right valve, male, × 8.
   Middle Clinton (*Mastigobolbina lata* zone, 120 feet above base) along Wills Creek, Cumberland, Md.
8. Squeeze of fairly typical right valve, male, × 8.
9. Right valve, male, not typical, × 8.
10. Exterior of right valve, male, × 8, doubtfully referred to this species. The outline is more rounded, the border thinner and wider and more deeply excavated than in the typical form.
    Middle Clinton (*Mastigobolbina lata* zone), eastern end Lavender Mt., Armuchee, Ga.
11. Left valve, female, × 8. Anterodorsal part of outline obscured by matrix.
    Middle Clinton, Gate City, Va.

FIGS. 12-19. ZYGOBOLBINA CONRADI LATIMARGINATA n. var. (see also Pl. XLII, Fig. 1) 565

12. Right valve, female, × 8.
    Middle Clinton, Eastern end of Lavender Mountain, Armuchee, Ga.
13. Gutta percha squeeze of right valve, male, × 8.
14. Sandstone slab with specimens, natural size.
    Middle Clinton (*Mastigobolbina lata* zone), New Hartford, N. Y.
15. Gutta percha squeeze of right valve, male, × 8.
    Middle Clinton, 300-325 feet above Tuscarora sandstone, ¾ mile south of Reedsville, Pennsylvania.
16. Left valve, male, gutta percha squeeze, × 8.
    Middle Clinton, 173 feet above Tuscarora sandstone, Cumberland, Md.
17. Right valve, male, × 8.
    Middle Clinton (120 feet above base) along Wills Creek, Cumberland, Md.
18. Right valve, female, × 8.
    Middle Clinton, Lavender Mountain, Armuchee, Ga.
19. Defective cast of interior, left valve, male, × 8, doubtfully referred to the variety.
    Top of lower Clinton, 8 feet above main seam, Frankstown ore bed. One-half mile northwest Frankstown, Pa.

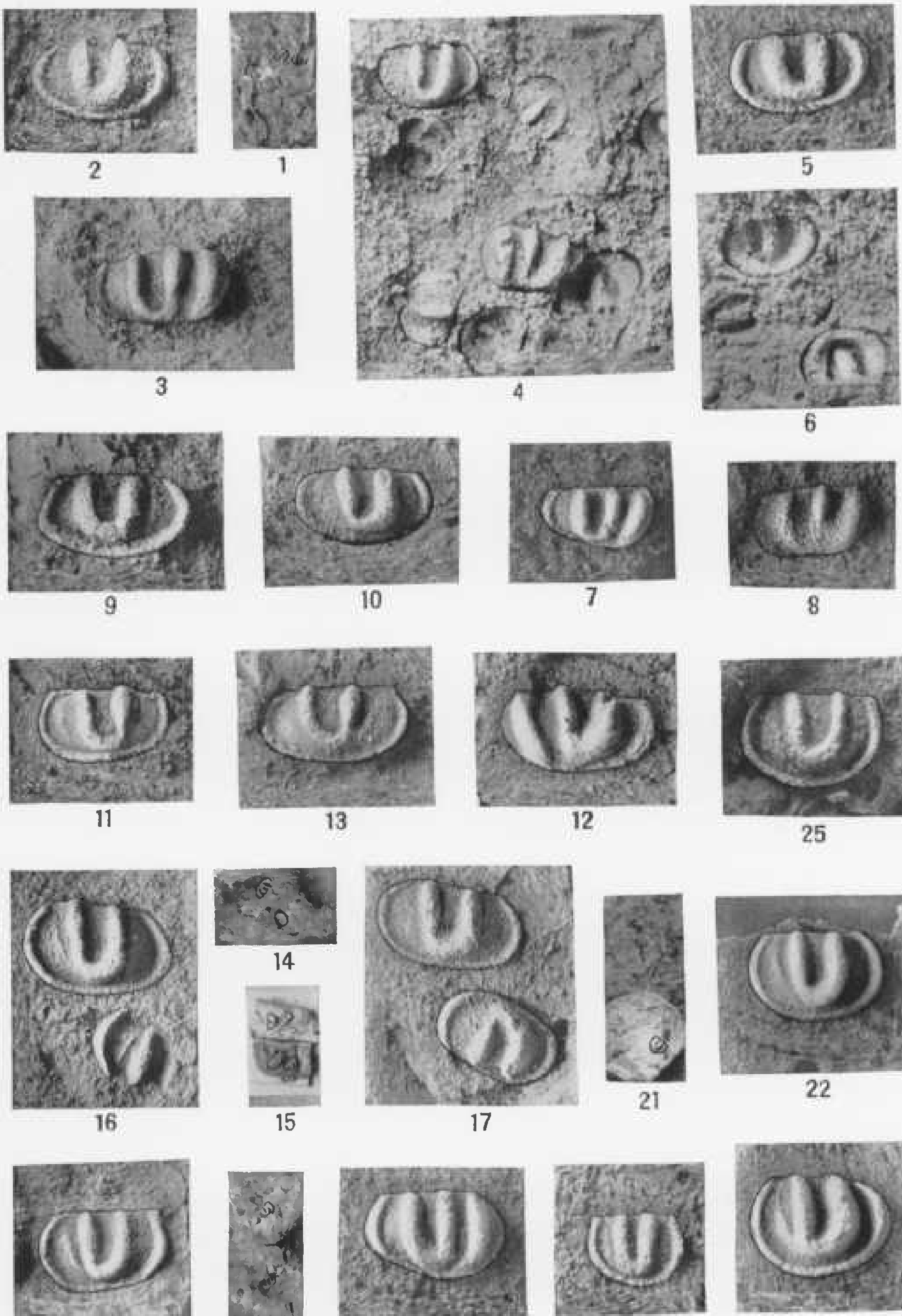
FIGS. 20-22. ZYGOBOLBINA PANDA n. sp. 566

20. Left valve, male, × 8.
21. Right valve, male, × 8.
22. Left valve, female, × 8.
    Top of lower Clinton, 8 feet above main seam of Frankstown ore bed. One-half mile northwest of Frankstown, Pa.



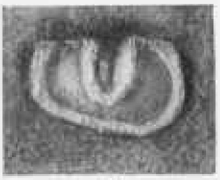
ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLIV



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLV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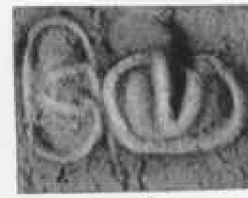
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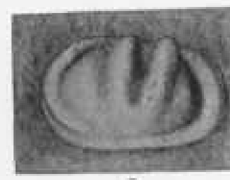
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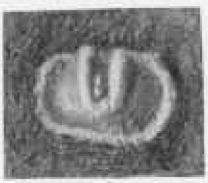
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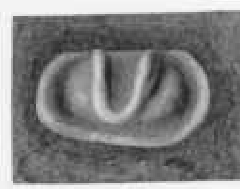
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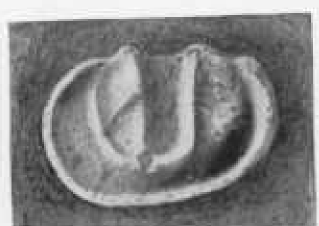
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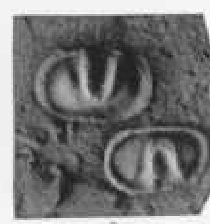
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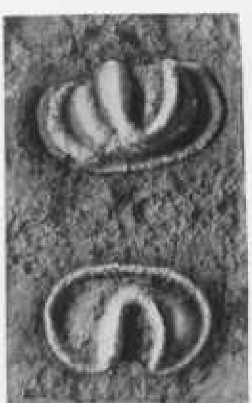
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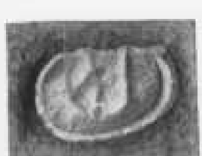
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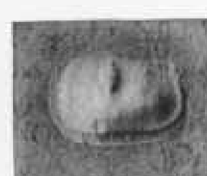
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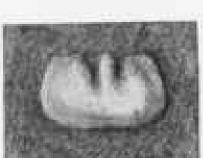
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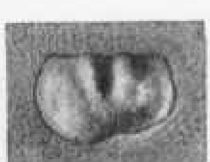
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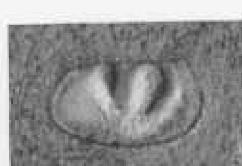
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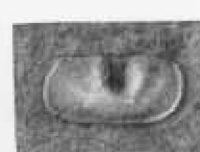
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ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLVI

PAGE

FIGS. 1-6. BONNEMAIA CELSA n. sp. 581

1. Right valve, male, × 8.

Upper Clinton (*Mastigobolbina typus* zone), 32 feet beneath base of Keefer sandstone, Flintstone, Md.

2, 3. Left valve, male, natural size and × 8.

4-6. Dorsal, lateral and ventral edge views of same, × 8.

Upper Clinton (*Mastigobolbina typus* zone), 23 feet beneath Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.

FIGS. 7-9. BONNEMAIA CRASSA n. sp. 582

7, 8. Testiferous right valve, male, natural size and × 8.

9. Ventral edge view of same, × 8.

Upper Clinton (*Mastigobolbina typus* zone), 23 feet beneath Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.

FIGS. 10-15. BONNEMAIA OBLIQUA n. sp. 584

10, 11. Gutta percha squeeze of large left valve, male, × 1 and × 8.

Upper Clinton (*Bonnemaia rudis* zone). Mulberry Gap, Powell Mt., 5 miles northwest of Sneedville, Tenn.

12. Natural cast of interior, left valve, male, × 8.

13. Natural cast interior right valve, male, × 8.

14. Natural cast interior, right valve, female, × 8.

Lower part of Upper Clinton, Wills Creek. Cumberland, Md.

15. Rough natural casts in sandstone of interior right male and left female valves, × 8. The brood pouch and adjacent parts of the female (upper figure) have been broken away.

Upper Clinton. State Line east of Rickard Mt., Williamsport quadrangle, Md.

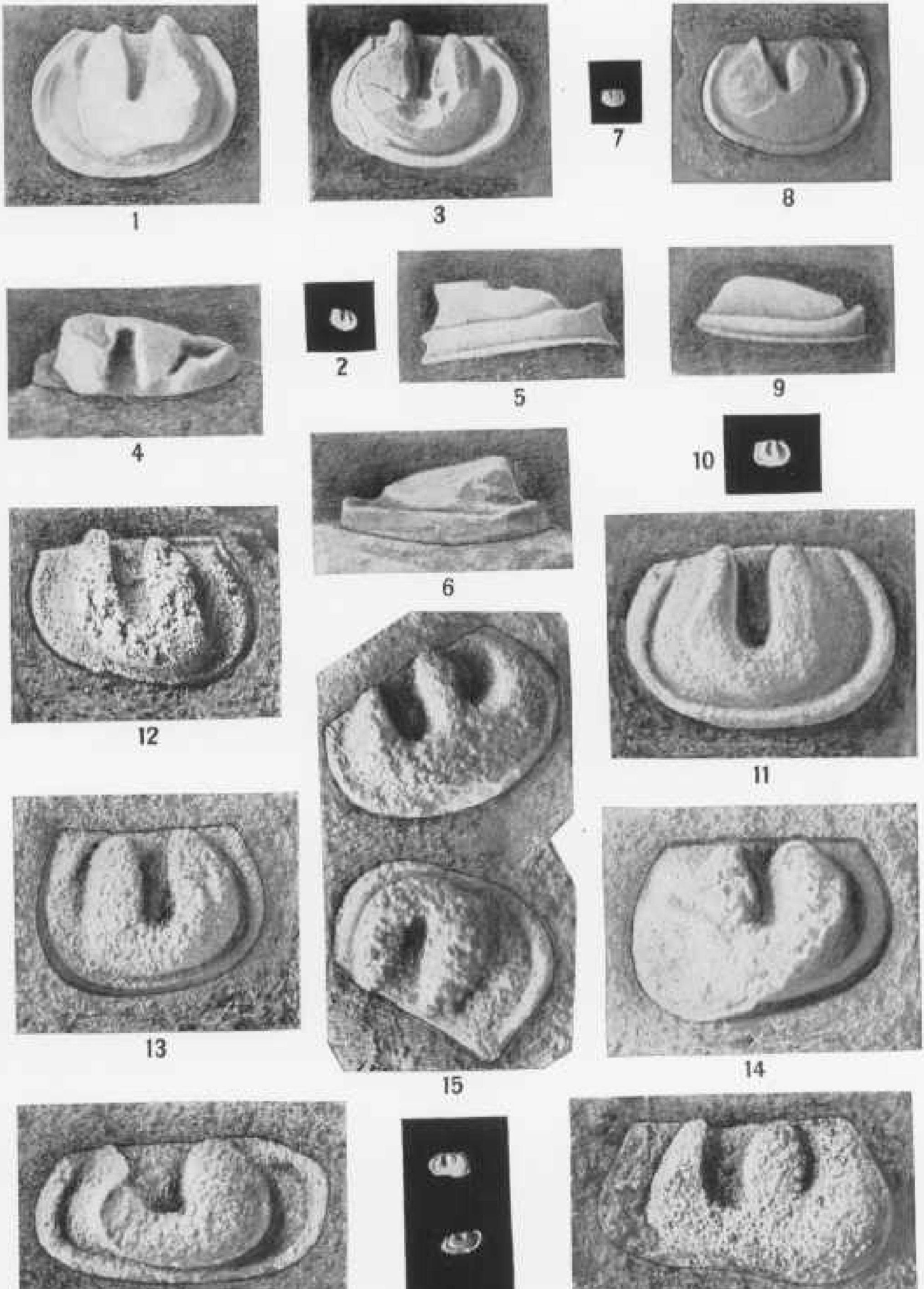
FIGS. 16-18. BONNEMAIA PERLONGA n. sp. 593

16. The type specimens, natural size, preserved in coarse sandstone.

17. Gutta percha squeeze of exterior of male valve, × 8. The roughened surface in this and the following figure is due to the coarseness of grain of the sandy matrix.

18. Gutta percha squeeze of exterior of imperfect left valve. female, × 8.

Upper Clinton. One mile west of Stone Cabin Gap, Williamsport quadrangle, Md.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLVII

1. Left valve, male, × 8.
2. A single valve, natural size.
3. Right valve, male, × 8.
4. Left valve, female, × 6.
5. Natural molds, × 4, on a slab of fine grained sandstone, containing numerous valves of *B. rudis*, *B. fissa*, *B.* cf. *longa*, *Mastigobolbina bifida* and other ostracoda commonly found in this zone.
6. Natural cast of the interior, right valve, female, × 8.

Lower part of Upper Clinton. (*Bonnemaia rudis* zone) Mulberry Gap, Powell Mt., 5 miles northwest Sneedville, Tenn.

7. Gutta percha cast of the exterior of three valves, natural size, the middle one being of this species, the other of *B. rudis*. The exterior molds of same specimens are shown, × 4, in the middle of the upper fourth of fig. 5.
8. Two of the same specimens, × 8, the one on the left showing the character of a typical male left valve, of *B. fissa*.
9. Male left valve, × 8.

Upper Clinton (*Bonnemaia rudis* zone). Mulberry Gap, Powell Mt., 5 miles northwest Sneedville, Tenn.

10. Gutta percha squeeze of right valve, male, × 8. Holotype.

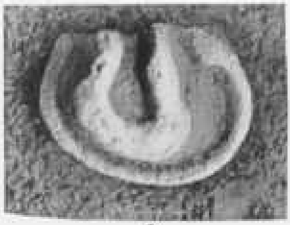
Upper Clinton (*Mastigobolbina typus* zone), Wills Creek, Cumberland, Md.

11, 12. Gutta percha squeeze of large left valve, female, natural size and × 8. Original preserved in shale and somewhat crushed. Doubtfully referred to this species, the median sulcus being abnormally wide and varying in other features from the holotype.

Upper Clinton (*Mastigobolbina typus* zone), 29 feet below Keefer sandstone, Sir Johns Run (Devil's Nose), Md.

Left valve, male, × 8, representing a longish variety that at first suggested possibly closer relations to *B. longa*.

Upper Clinton (*Bonnemaia rudis* zone). Mulberry Gap, Powell Mt., 5 miles northwest of Sneedville, Tenn.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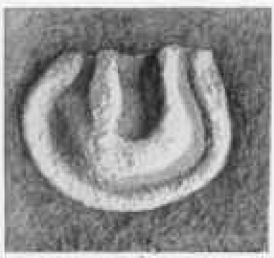
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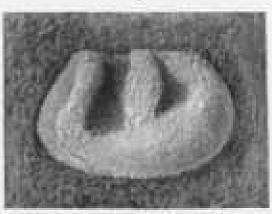
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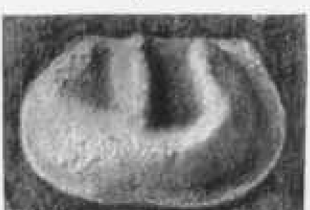
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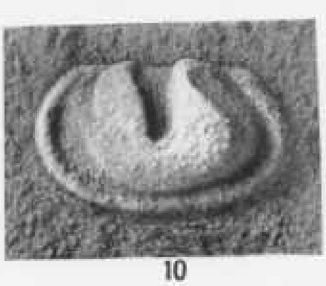
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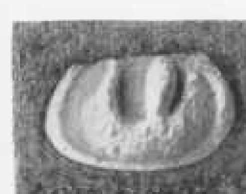
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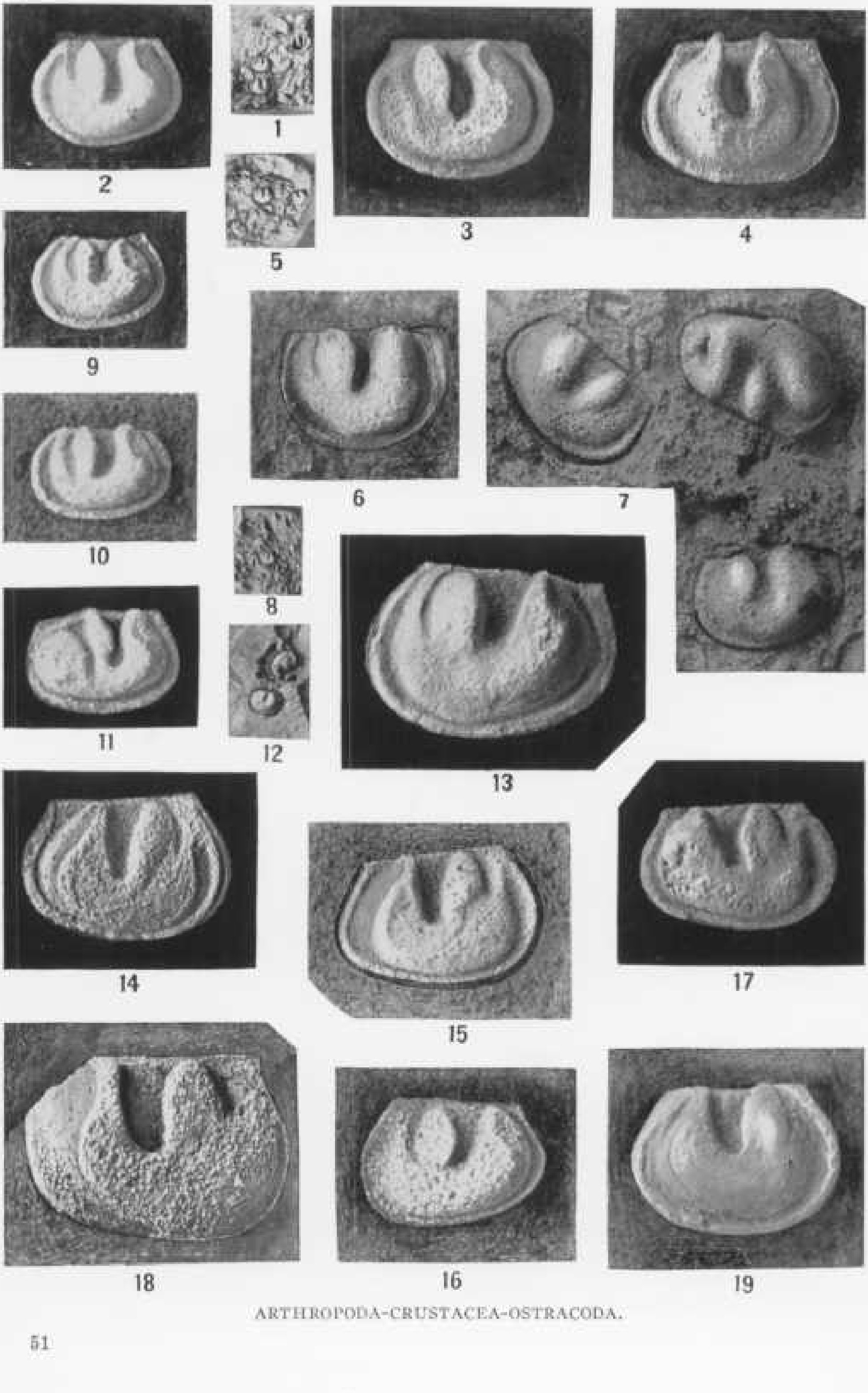
ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLVIII



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE XLIX

PAGE

FIGS. 1-6. MASTIGOBOLBINA TYPUS n. sp. 602

1. Fragment of sandstone with numerous molds of this and other species of ostracoda, natural size.
2. Gutta percha cast of the same, natural size.
3. Gutta percha cast of two male valves of the variety *angulata*, × 6, associated with two valves of the smaller ostracode *Zygosella vallata* and with *Tentaculites*.
4. Gutta percha casts of two left female valves, × 6, associated with a valve of *Zygosella vallata* and one of *Bonnemaia* sp.

    Upper Clinton (*Mastigobolbina typus* zone), 29 feet below Keefer sandstone. Near Six-Mile House, Md.
5. Testiferous left valve, female, × 8, with flagellum broken away.

    Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.
6. Cast of interior of left valve, male, × 6.

    Upper Clinton (*Mastigobolbina typus* zone), 23 feet below Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.
7. Testiferous left valve of female, × 8, with flagellum preserved.

    Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.
8. Inner side of ventral edge of female right valve, × 20, showing thin ridges and furrows used in locking the closed valves.

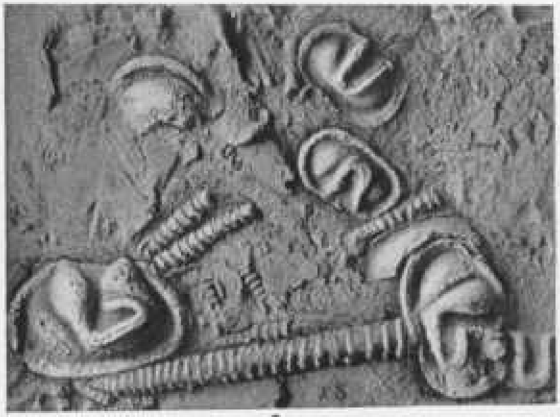
    Upper Clinton (*Mastigobolbina typus* zone), Hollidaysburg, Pa.
9. Right valve, female, × 8, with ventral curve of flagellum broader than usual.
10. Right valve, male, × 6, with summits of median and anterior lobes broken but otherwise in excellent preservation.

    Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.
11. Imperfect testiferous left valve, female, × 6.

    Upper Clinton (*Mastigobolbina typus* zone), 23 feet below Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.
12. Gutta percha squeeze of mold, left valve of male, × 6, of variety *angulata* showing the characteristic elbow-like angulation of the ventral extremity of the flagellum and the low convexity of the valves.
13. Squeeze of mold of left valve, female, × 6.
14. Ventral edge view of same, × 6.

15, 16. Left valve of female and dorsal edge view, × 6, of a doubtful specimen which is relatively too short and the form and course of the flagellum different from *M. typa*. The specimen may be a female valve of *M. intermedia* or a similar species.

Upper Clinton, 77 feet beneath top of Keefer sandstone. Six-Mile House, Md.



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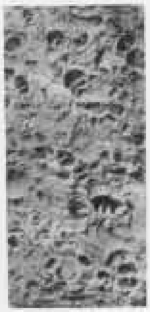

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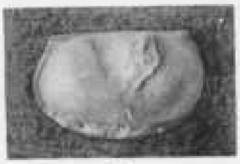

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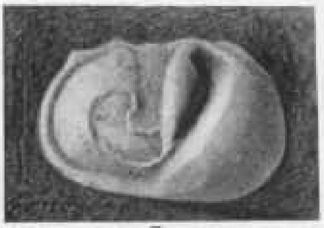

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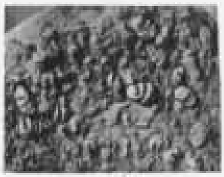

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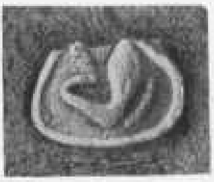

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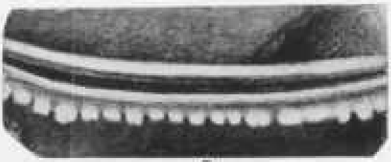

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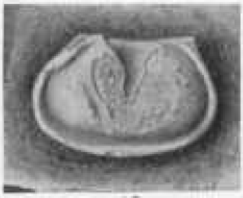

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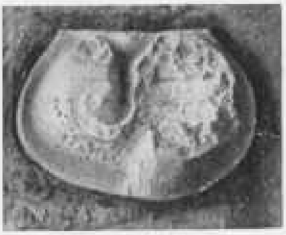

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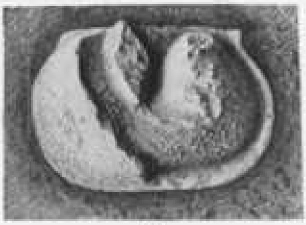

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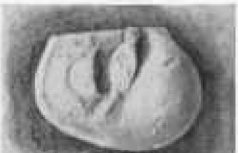

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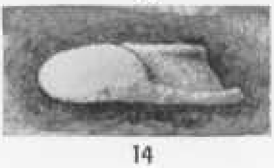

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ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE L

PAGE

FIGS. 1-4. MASTIGOBOLBINA TRIPLICATA (Fœrste) 605

1, 2. Two testiferous right valves, male, × 8.

3. Left male valve, × 8.

4. Right valve of female, × 8.

Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.

FIG. 5. MASTIGOBOLBINA TYPUS PRÆNUNTIA n. var 602

The holotype—a left valve, × 12.

Near base of Upper Clinton (*Bonnemaia rudis* zone). Mulberry Gap, Powell Mountain, 5 miles northwest Sneedville, Tenn.

FIGS. 6-10. MASTIGOBOLBINA ARGUTA n. sp 607

6. A right valve, female, × 8.

7, 8. Left valve of female, × 8, with ventral edge view of same. The inner edge of the brood pouch is so nearly straight and the post ventral part so full in this specimen that it is doubtfully referred here. Possibly it belongs with *M. intermedia.*

9. Testiferous right valve of male, × 8.

Upper Clinton (*Mastigobolbina typus* zone). Lakemont, Pa.

10. Male right valve, × 8, of incomplete specimen representing a variety.

Upper Clinton (*Mastigobolbina typus* zone), 23 feet beneath Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.

FIG. 11. MASTIGOBOLBINA ROTUNDA n. sp 610

The type specimen, a left valve, male, × 12.

Upper Clinton (*Mastigobolbina typus* zone), 23 feet beneath Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.

FIGS. 12-15. MASTIGOBOLBINA INTERMEDIA n. sp 609

12. Testiferous left valve, male, × 12.

13, 14. Two left valves, male, × 12, with part of shell broken away.

15. Left valve of female, × 12.

Upper Clinton (*Mastigobolbina typus* zone). Lakemont, Pa.

FIGS. 16-17. MASTIGOBOLBINA TRILOBATA n. sp 612

16. Testiferous left valve, male, × 12.

17. Right valve, male, × 12, also preserving test.

Upper Clinton (*Mastigobolbina typus* zone). Lakemont, Pa.

FIGS. 18-20. MASTIGOBOLBINA ARCTILIMBATA n. sp 613

18, 19. Two views, × 6 and × 12, of the type specimen, a testiferous left valve, male.

Upper Clinton (*Mastigobolbina typus* zone), 23 feet beneath Keefer sandstone, 1½ miles east of Great Cacapon, W. Va.

20. Cast of the interior in limestone, × 12, a small left valve, male.

Upper Clinton (*Mastigobolbina typus* zone). Lakemont, Pa.

FIG. 21. MASTIGOBOLBINA GLABRA n. sp 614

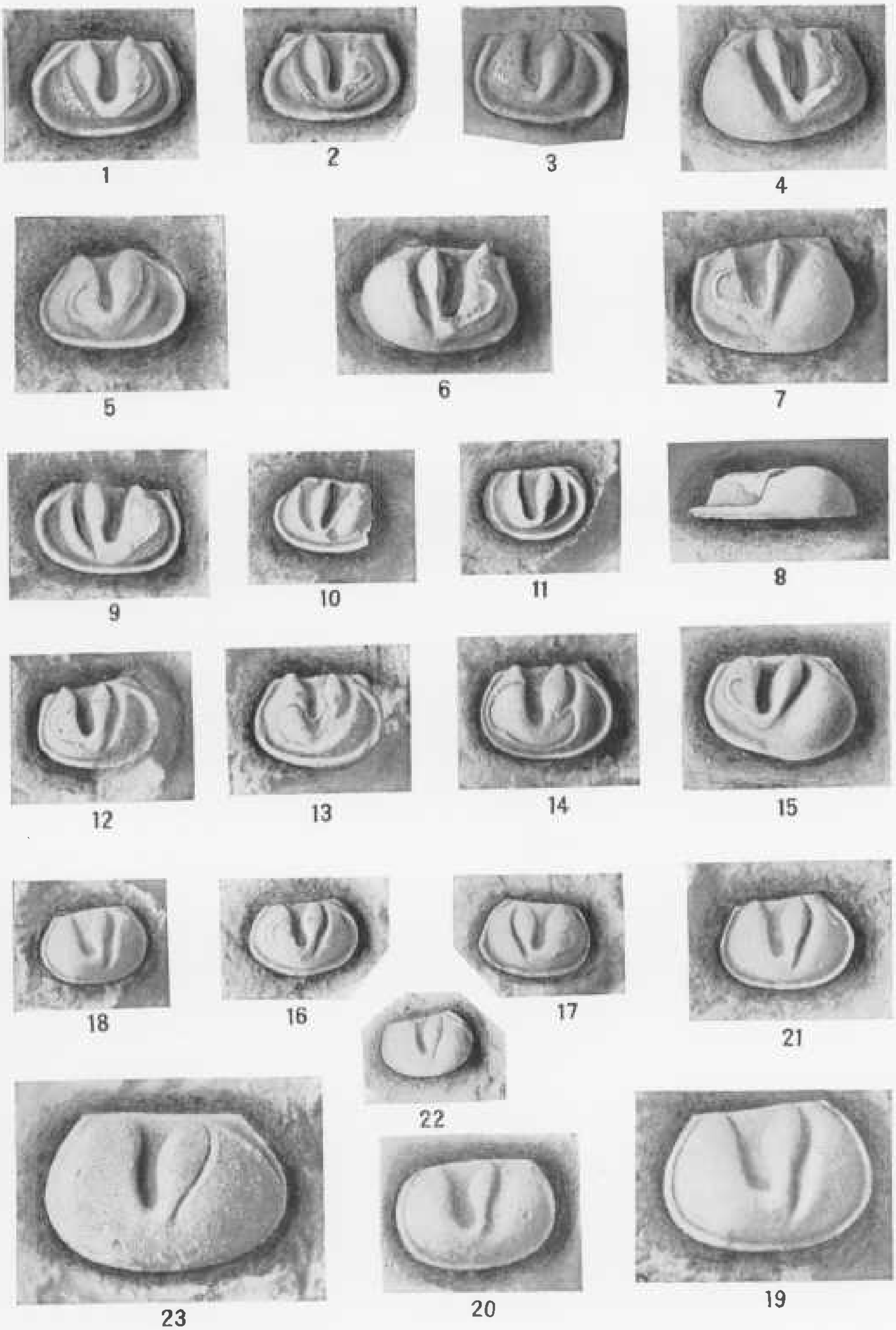
A perfect left valve, male, × 12.

Upper Clinton, (*Mastigobolbina typus* zone). Lakemont, Pa.

FIGS. 22, 23. MASTIGOBOLBINA PUNCTATA n. sp 615

The holotype, × 8 and × 20, a perfect left valve, male, showing the punctate surface.

Upper Clinton (*Mastigobolbina typus* zone). Lakemont, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LI

PAGE

FIGS. 1-11. MASTIGOBOLBINA LATA (Hall) (see also Plate LII, Figs 5, 6).. 620

1. Gutta percha squeeze, left valve, × 8, from a natural mold in rather coarse-grained sandstone.
   Middle Clinton (*Mastigobolbina lata* zone), 120 feet above base, Cumberland, Md.
2. Gutta percha squeeze of left valve, male, × 8. The natural mold from which this was prepared, retains some of the ferruginous replacement of the shell.
3. Gutta percha squeeze, × 8, of male valve with produced dorsal extremity of anterior lobe.
4. Cast of interior, left valve, male, × 8.
   Middle Clinton (*Mastigobolbina lata* zone), New Hartford, N. Y.
5. Gutta percha squeeze, right valve, × 8.
   Middle Clinton (*Mastigobolbina lata* zone), 120 feet above base, Cumberland, Md.
6. Left valve, male, × 8, from Hall's type lot. This specimen is uncommonly elongate and the crest of the anterior lobe is poorly defined. In both respects it reminds of *M. vanuxemi* to which it should perhaps be referred.

7, 8. Natural casts of interior, right and left female valves, × 8.

9. Left valve, female, × 8, from original types.
10. Surface of Hall's original type slab, × 2. 1, types as here restricted, casts of the interior of a right and a left valve of the male and a mold of the exterior of a female; 2, casts of the exterior, left valves, males.
11. Gutta percha squeeze of right valve, male, × 8, prepared from cleanest natural mold available and therefore best showing the exterior of the valves.
    Middle Clinton (*Mastigobolbina lata* zone), New Hartford, N. Y.

FIGS. 12-17. MASTIGOBOLBINA LATA NANA n. var........................ 626

12, 13. Two right valves, × 8, distorted, mainly shortened, by pressure. The larger may belong to the typical variety of the species or to *M. declivis*.

14. Natural cast of left female valve, × 8.
15. Gutta percha squeeze of a large right valve, male, × 8, reduced in height by pressure.
    Middle Clinton (*Zygobolbina emaciata* zone), Toll-gate, Cove Gap, Tuscarora Mt., 4½ miles northwest of Mercersburg, Pa.

16, 17. Gutta percha squeezes of male right and left valves, × 8. The small size of the species is indicated by comparison with the incompletely exposed valve of *M. lata* lying beside it in the upper figure.
Middle Clinton (*Mastigobolbina lata* zone), New Hartford, N. Y.

FIGS. 18-20. MASTIGOBOLBINA CLARKEI n. sp............................ 629

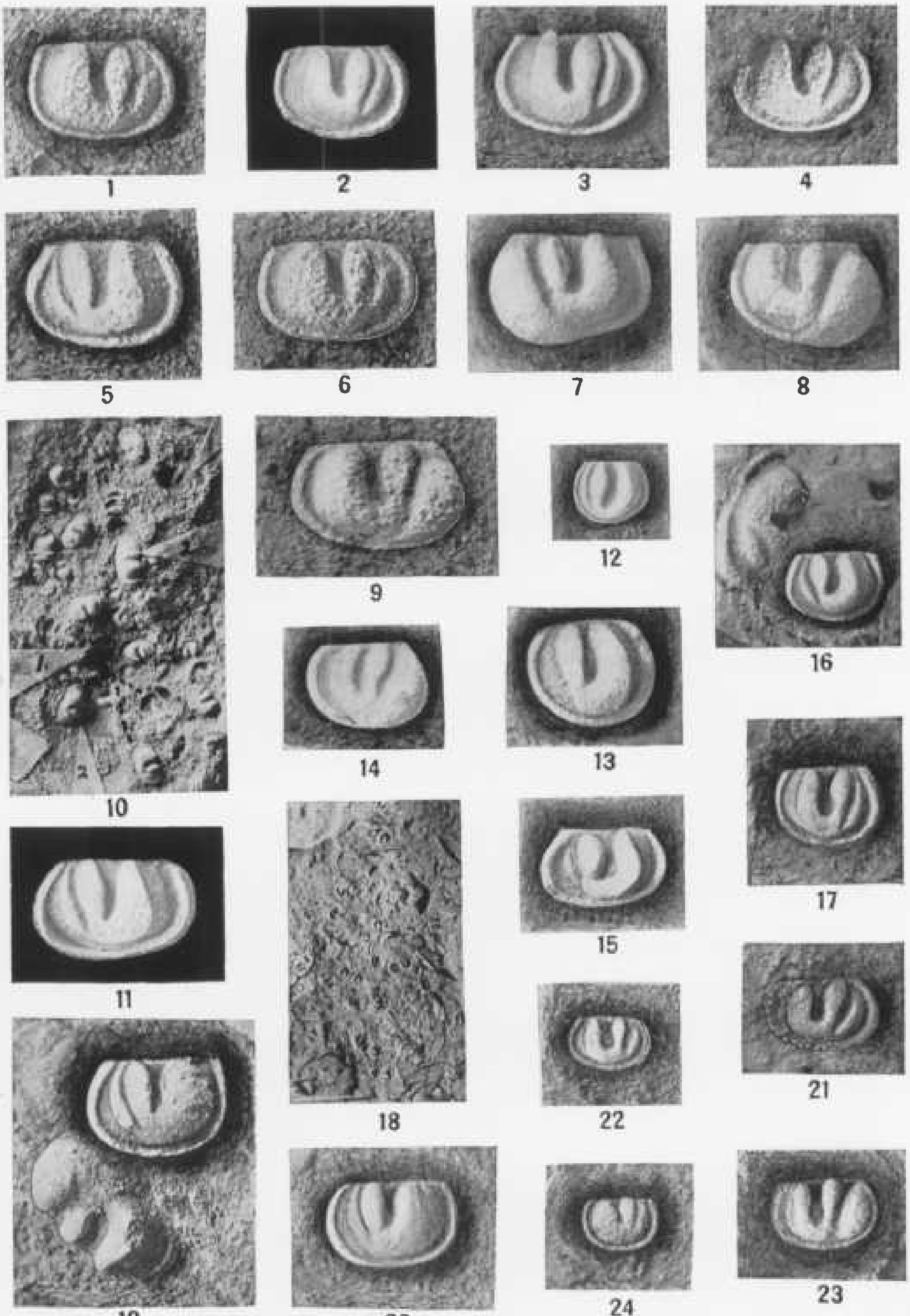
18. Natural size, view of surface of sandstone slab with impressions of valves of this and other species of its zone, *M. lata* is represented but most of the impressions are of *Zygobolbina conradi*.
19. Right valve, male, × 8, figured by Ulrich and Bassler in 1908 as *Beyrichia lata* Hall, and also left valve of female of *M. lata*.
    Middle Clinton (*Mastigobolbina lata* zone), New Hartford, N. Y.
20. Right valve of male, × 8.
    Middle Clinton (*Mastigobolbina lata* zone). Three-fourths mile south of Reedsville, Pa.

FIGS. 21-23. MASTIGOBOLBINA ULTIMA n. sp............................ 618

21. Gutta percha squeeze, large left valve, male, × 8.
22. Small left valve, male, × 8.
23. Left valve, female, ×8.
    Upper Clinton (*Bonnemaia rudis* zone), 102 feet beneath top of Keefer sandstone. Near Six-Mile House, Md.

FIG. 24. MASTIGOBOLBINA MICULA n. sp................................ 616

Gutta percha squeeze, left valve, male, × 8.
Upper Clinton (*Bonnemaia rudis* zone), 102 feet below top of Keefer sandstone. Near Six-Mile House, Md.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LII

PAGE

FIGS. 1-4. MASTIGOBOLBINA VANUXEMI n. sp. 627
1. Natural cast of the interior of a right valve, × 8.
2. Natural cast of the interior of a smaller left valve, × 8.
Middle Clinton (*Mastigobolbina lata* zone). New Hartford, N. Y.
3. Surface of sandstone slab, natural size, showing numerous specimens of *M. vanuxemi* and *M. lata*.
Middle Clinton (*Mastigobolbina lata* zone), 120 feet above Tuscarora sandstone, Cumberland, Md.
4. Gutta percha squeeze of right valve, male, of a variety, × 8.
Middle Clinton, 100 feet above iron-ore bed (*Mastigobolbina lata* zone), Cumberland Gap, Tenn.

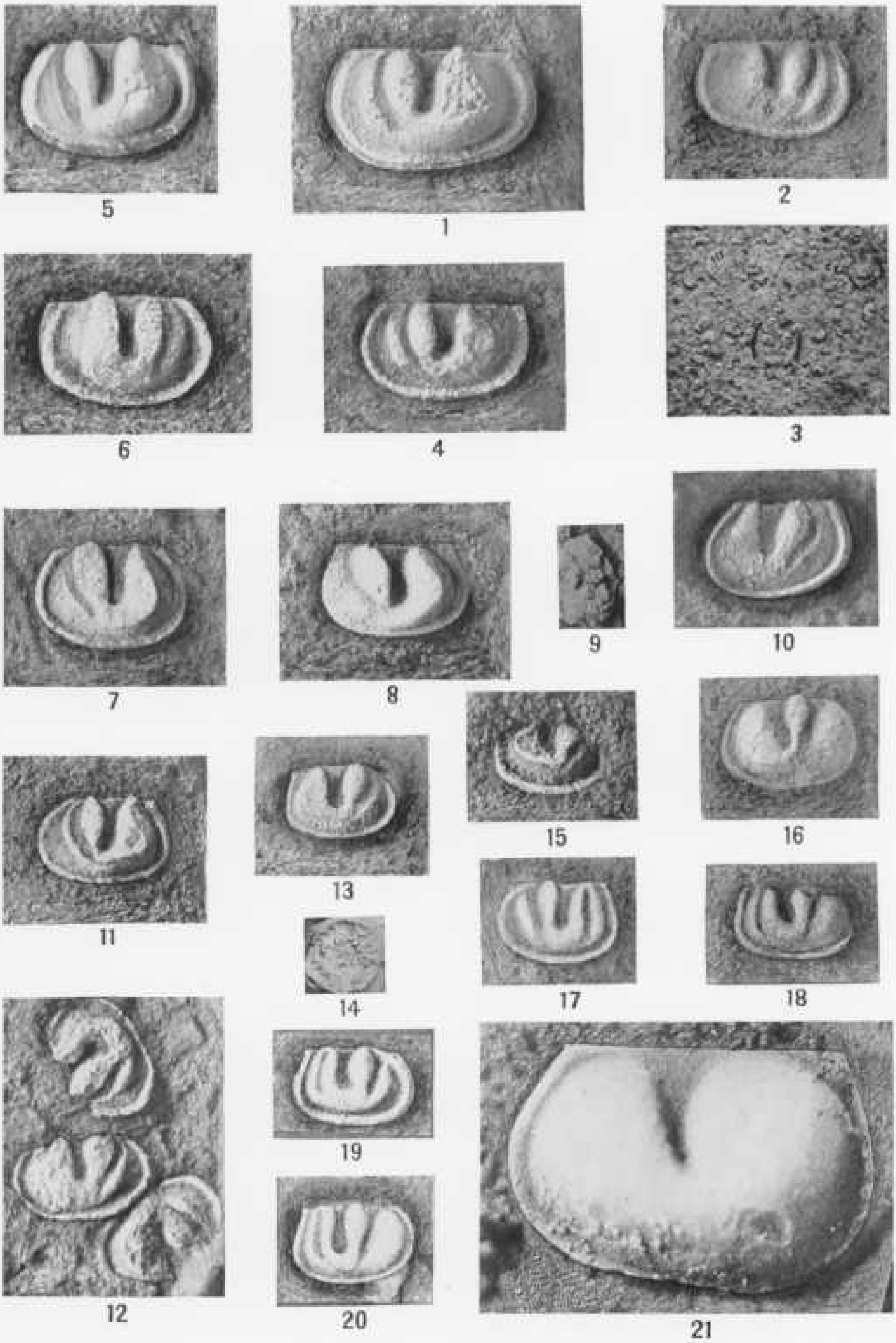
FIGS. 5, 6. MASTIGOBOLBINA LATA (Hall) Ulrich and Bassler. (See also Plate LI, Figs. 1-11) 620
5. Natural cast of interior, right valve, male, × 8. The specimen is uncommonly large for the species but has suffered slight abrasion of the anterior lobe and loss of the crest of the ridge.
6. Gutta percha squeeze of large left valve, male, × 8. Differences between this and Fig. 5 are mainly because this shows the exterior of the valve whereas that is a cast of the inner surface.
Middle Clinton (*Mastigobolbina lata* zone), 120 feet above top of Tuscarora sandstone, Cumberland, Md.

FIGS. 7-10. MASTIGOBOLBINA DECLIVIS n. sp. 630
7. Gutta percha squeeze, exterior, right valve, male, × 8.
8. Natural cast of interior, right valve, male, × 8.
9. Several valves, natural size.
10. Gutta percha squeeze, exterior left valve, male, × 8. Specimen slightly distorted by pressure and tilted so as to depress the anterior border and narrow the steep slope of the anterior lobe.
Middle Clinton (*Zygobolbina emaciata* zone), Cove Gap, Tuscarora Mountain, 4½ miles northwest of Mercersburg, Pa.

FIGS. 11-16. MASTIGOBOLBINA MODESTA n. sp. 611
11. Gutta percha squeeze of right valve, male, × 8.
Middle Clinton (*Mastigobolbina lata* zone), New River, 1 mile west of Narrows, Va.
12. Squeeze of exterior of two right and one left valve, × 8.
13. Natural cast of interior, × 8, retaining impression of the high and thin border on the posterior side.
14. Valves, natural size.
15. Gutta percha squeeze of ventral two-thirds of exterior male left valve, × 8, showing the strongly bowed and prominent flagellum.
Middle Clinton (*Mastigobolbina lata* zone). Gap, 1½ miles northwest of Warm Springs, Va.
16. Natural cast, interior left valve, female, × 8.
Middle Clinton (*Mastigobolbina lata* zone), New River, 1 mile west of Narrows, Va.

FIGS. 17-20. MASTIGOBOLBINA (?) BIFIDA n. sp. 617
17 and 19. Gutta percha squeezes, exterior right and left valves, respectively, males, × 8.
18. Squeeze, exterior left valve, female, × 8, the dorsal edge and post dorsal region wanting and tilted so as to show more of the ventral slope.
20. Gutta percha squeeze, exterior left valve, female, × 8, showing the brood pouch lying within the elevated borders.
Upper Clinton (*Bonnemaia rudis* zone), Mulberry Gap, Powell Mountain, 5 miles northwest of Sneedville, Tenn.

FIG. 21. PLETHOBOLBINA TYPICALIS n. sp. (See also Plate LIII, Figs. 28-33.) 636
Left valve, × 12.
Upper Clinton (*Mastigobolbina typus* zone), 1½ miles east of Great Cacapon, W. Va.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LIII

PAGE

FIGS. 1-7. MASTIGOBOLBINA RETIFERA n. sp. 634

1. Valve, natural size.
2. Perfect natural mold, exterior left valve, male, × 8.
3. Testiferous left valve, male, × 8, showing surface reticulation. The lobes were injured in freeing the specimen from the matrix.
4. Testiferous right valve, male, × 8, exhibiting border and lower half of surface.
5. Partial cast of interior of left valve, female, × 8, with indications of the exterior surface punctation.
6. Cast interior right valve, male, × 8, showing form of post median lobe and course of crest of anterior lobe along its inner side.
7. Similar cast right valve, female, × 8, with border lacking.

Top of Lower Clinton, 8 feet above main ore seam, ½ mile northwest of Frankstown, Pa.

FIGS 8-12. MASTIGOBOLBINA INCIPIENS n. sp. 632

8. Valve, natural size.
9. Gutta percha squeeze, × 8, of right, male valve retaining, showing duplex character of border.
10. Cast interior left valve, male, × 8.
11. Similar cast of female left valve, × 8. As in Fig. 10, most of the border is wanting.
12. Anterior two-thirds of cast interior of left valve, × 20, showing muscular scars. The marginal depression is made by the inner border. The hollow base of the wide outer border makes the low intramarginal ridge in which parts of both are shown.

Top of Lower Clinton, 8 feet above main ore seam, ½ mile northwest of Frankstown, Pa.

FIGS. 13-17. MASTIGOBOLBINA PRODUCTA n. sp. 633

13. Cast interior male left valve, × 8, somewhat shorter than usual.
14. Interior cast of right male valve of the elongate typical form, × 8.
15. Inner side of male left valve, × 8. The outer border extends into the matrix from the dark line on the inner edge of the light colored impression of the inner border.
16. Gutta percha squeeze of original, Fig. 15, × 8.
17. Cast interior right valve, male, × 8, retaining a bit of the ventral border.

Top of Lower Clinton, 8 feet above main ore seam, ½ mile northwest of Frankstown, Pa.

FIGS. 18-20. PLETHOBOLBINA ORNATA n. sp. 636

18, 19. The type specimen, a left valve, × 8 and × 20, showing the finely reticulated surface.

20. Same valve, natural size.

Upper Clinton (*Mastigobolbina typus* zone), 2 miles west of Hollidaysburg, Pa.

FIGS. 21, 22. PLETHOBOLBINA CORNIGERA n. sp. 637

The type specimen, × 8, and natural size, showing the characteristic horn-like node on the dorsal edge.

Upper Clinton (*Mastigobolbina typus* zone), 2 miles west of Hollidaysburg, Pa.

FIGS. 23, 24. PLETHOBOLBINA CRIBRARIA n. sp. 637

Right and left valves, × 12, illustrating outline and reticulate surface.

Lower Clinton, 57 feet above top of Tuscarora sandstone, Cumberland, Md.

FIGS. 25-27. PLETHOBOLBINA SULCATA n. sp. 638

25, 26. Right and left valves, × 12, both slightly distorted.

27. Valve, natural size.

Middle Clinton (*Zygobolbina emaciata* zone), Toll-Gate, Cove Gap, 4½ miles northwest Mercersburg, Pa.

FIGS. 28-33. PLETHOBOLBINA TYPICALIS n. sp. 636

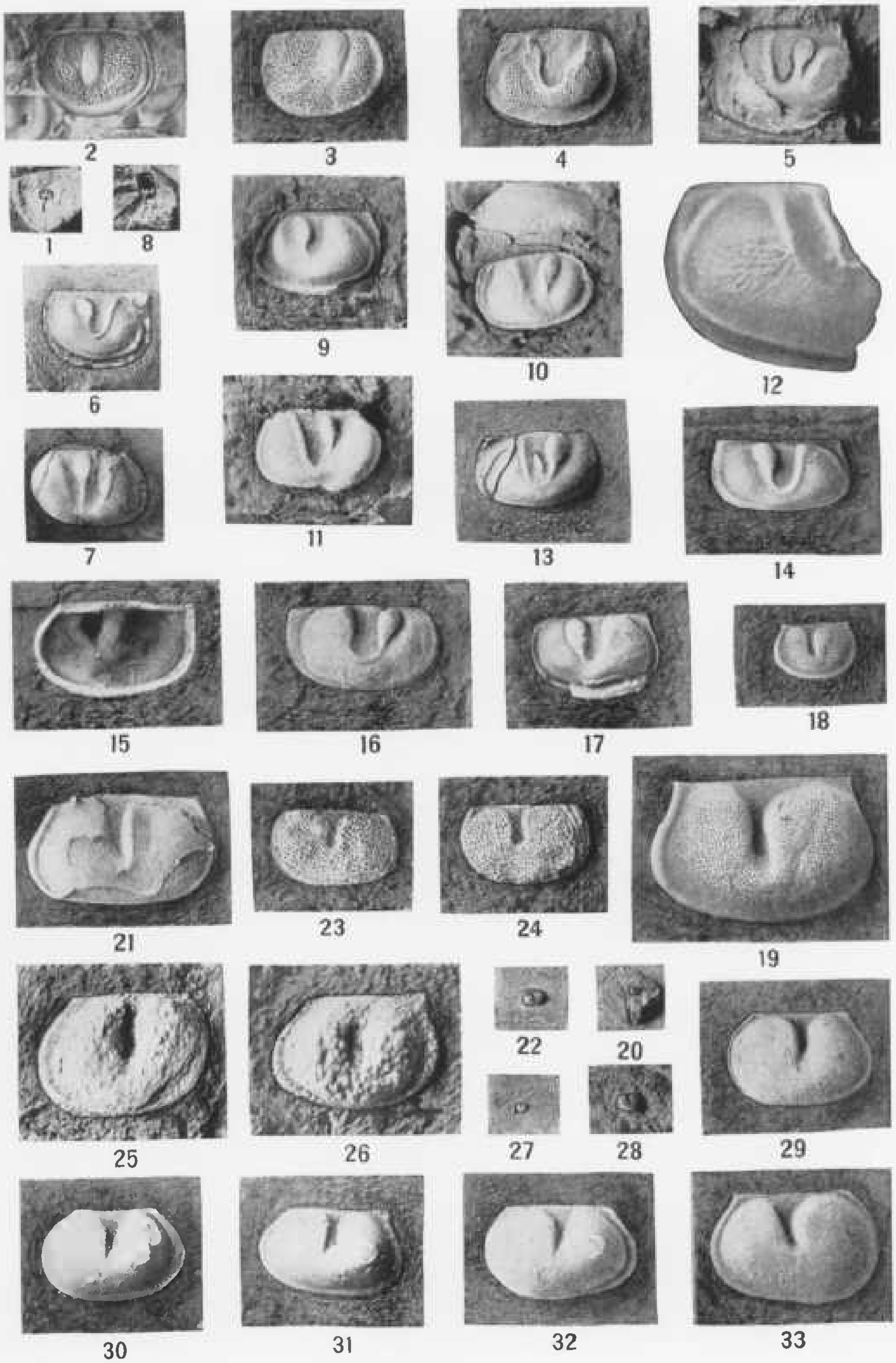
28. Average valve, natural size.
29. Quite perfect, small right valve, × 6.

30, 31. Two right valves, × 6.

Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.

32. Nearly perfect right valve, × 6, fuller than usual in the post ventral quarter and possibly a female.
33. Large left valve (female ?), × 6, with shell partly denuded. (See also Pl. LII, Fig. 21.)

Upper Clinton (*Mastigobolbina typus* zone), 1½ miles east of Great Cacapon, W. Va.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LIV

PAGE

FIGS. 1, 2. ZYGOBEYRICHIA REGINA n. sp. 645

1. Left valve, female, × 12.
2. Typical male left valve, × 12, exhibiting the border and the almost straight ventral edge.

Tonoloway formation (upper part), Keyser, W. Va.

FIGS. 3-5. ZYGOBEYRICHIA TONOLOWAYENSIS n. sp. 645

3. Male left valve, × 12, showing convex ventral outline.
4. Another male left valve, × 12.
5. Right valve, × 12.

Tonoloway formation (upper part), Keyser, W. Va.

FIGS. 6-8. ZYGOBEYRICHIA VENTRICORNIS n. sp. 646

6, 7. Right and left valves, male, of typical form, × 12.

Wills Creek formation (182 feet above base), Flintstone, Md.

8. Two male left valves, × 12.

Wills Creek formation (45 feet above base), Pinto, Md.

FIGS. 9, 10. ZYGOBEYRICHIA VENTRICORNIS OBSOLETA n. var. 646

Two male right valves of this variety, × 12, characterized by the absence of the ventral node. These two differ from each other in the relative length of the hinge line.

Wills Creek formation (187 feet above base), 3 miles west of Hancock, Md.

FIG. 11. ZYGOBEYRICHIA VENTRICORNIS var. 646

A small left valve, × 12, with a peculiar ventral elevation, provisionally referred here.

Tonoloway limestone (upper part), Keyser, W. Va.

FIG. 12. ZYGOBEYRICHIA MODESTA n. sp. 647

Male left valve, × 20.

Tonoloway formation (128 feet above base), Grasshopper Run, near Hancock, Md.

FIGS. 13, 14. ZYGOBEYRICHIA INCIPIENS n. sp. 646

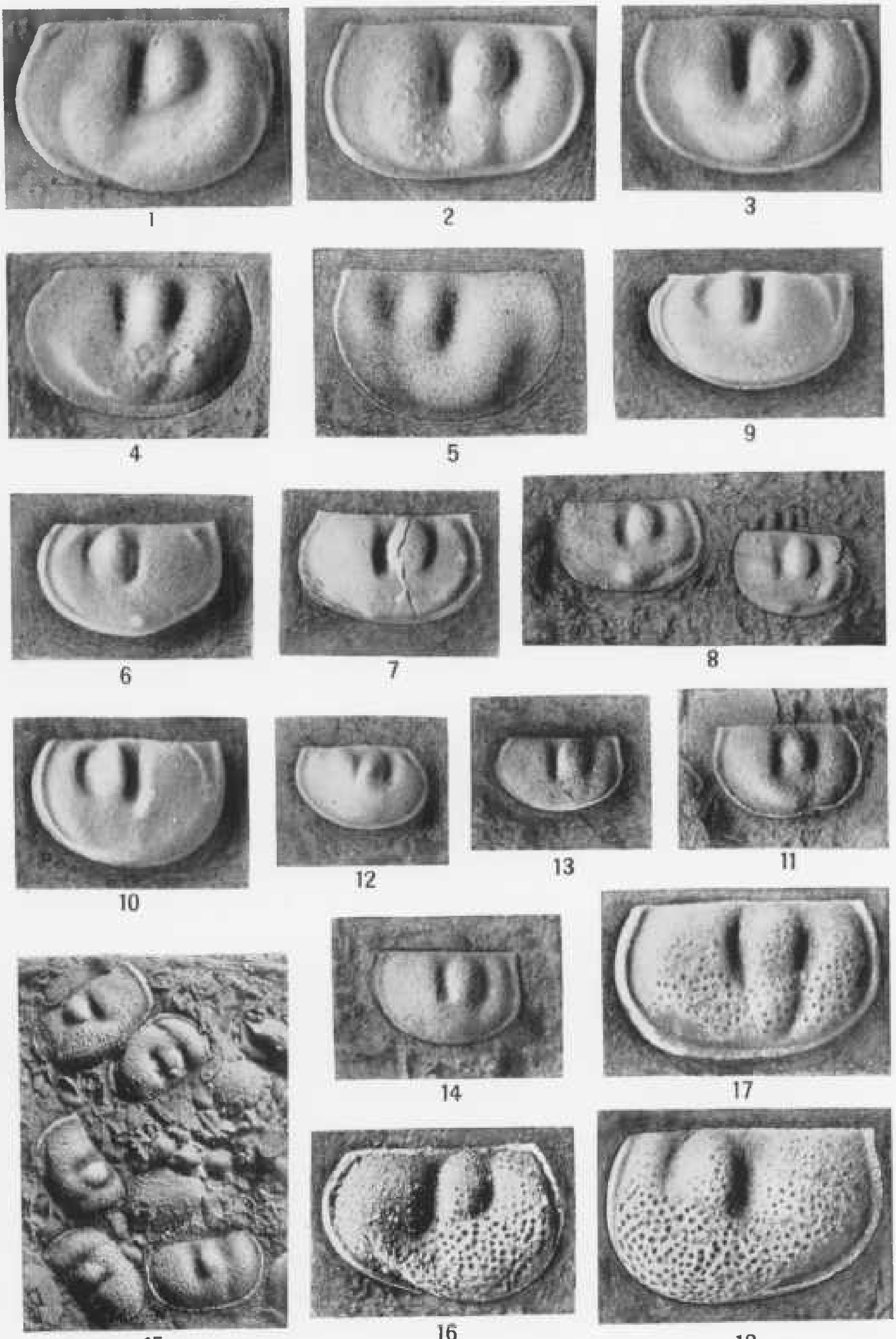
Two male left valves, × 12, upon which the species is founded and showing the ventral obsolescence of the border.

Wills Creek formation (45 feet above base), Pinto, Md.

FIGS. 15-18. ZYGOBEYRICHIA VENTRIPUNCTATA n. sp. 645

15. Limestone fragment, × 6, showing abundance of this ostracode.
16. Female left valve, × 12, showing decided punctæ on brood pouch.
17. Male left valve, × 12.
18. Female right valve, × 12.

Tonoloway formation (upper part), Keyser, W. Va.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LV

		PAGE
FIGS. 1-5.	KYAMMODES TRICORNIA n. sp.	644

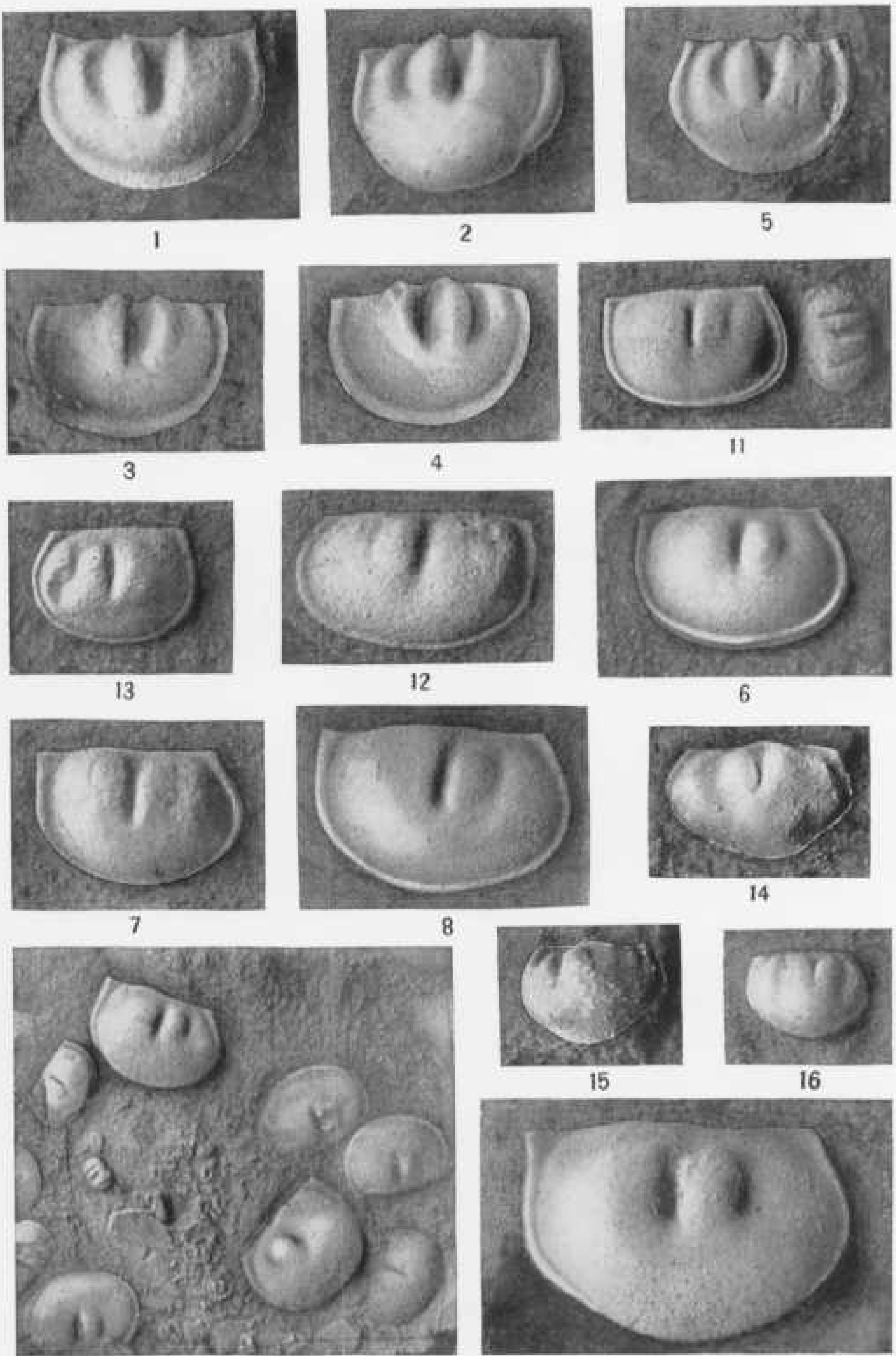
1, 2. Right valves of male and female, respectively, × 16.
3, 4. Right and left valves of male, × 16.
5. Variety with shorter hinge line, × 16.
McKenzie formation (77-82 feet below top), Flintstone, Md.

FIGS. 6-10. WELLERIA OBLIQUA n. sp. 642
6. Slightly shortened left valve of male, × 12.
7. Left valve, × 12.
8. Typical left valve of male, × 12.
9. Surface of slab, × 6, illustrating abundance of this species.
10. Left valve of female, × 12, showing the overhanging ventral pouch.
Tonoloway formation (lower part). Keyser, W. Va., and Grasshopper Run, 5 miles above Hancock, Md. (Figs. 6, 10).

FIGS. 11, 12. WELLERIA OBLIQUA LONGULA n. var. 642
11. A left valve of male, × 12, on slab with *Dizygopleura halli*.
12. A small specimen, × 20, doubtfully referred to this variety.
Tonoloway formation (lower part), Keyser, W. Va.

FIG. 13. WELLERIA OBLIQUA BREVIS n. var. 643
Right valve, × 12, showing dorsally converging terminal outlines and relatively short form.
Tonoloway formation (lower part), Keyser, W. Va.

FIGS. 14-16. KYAMMODES SWARTZI n. sp. 643
14, 15. Two right valves, × 12, showing subpentagonal form and projecting ventral slope.
16. Left valve, × 12, illustrating shortness of sulci.
Tonoloway formation (lower part), Grasshopper Run, 5 miles above Hancock, Md.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LVI

PAGE

FIGS. 1, 2. DREPANELLINA MODESTA n. sp. 649

Right and left valves, × 12, upon which this species is founded.

Upper Clinton (*Drepanellina clarki* zone), Cumberland, Md.

FIG. 3. DREPANELLINA (?) SIMPLEX n. sp. 649

The type, a right valve, × 20, showing resemblance to *Kyammodes.*

Upper Clinton (*Drepanellina clarki* zone), Lakemont, Pa.

FIG. 4. DREPANELLINA CLAYPOLEI n. sp. 650

Right valve, × 12, illustrating oblique shape and sharp anterior dorsal angle.

Upper Clinton, Juniata Co., Pa.

FIGS. 5, 6. DREPANELLINA VENTRALIS n. sp. 650

5. Typical left valve, × 20, exhibiting transverse ventral elevation.
6. Left valve, × 20, of a variety with slightly shorter hinge and inturned angles.

Upper Clinton (*Drepanellina clarki* zone), 34 feet above Keefer sandstone at Rose Hill, Md.

FIGS 7-9. DREPANELLINA CONFLUENS n. sp. 649

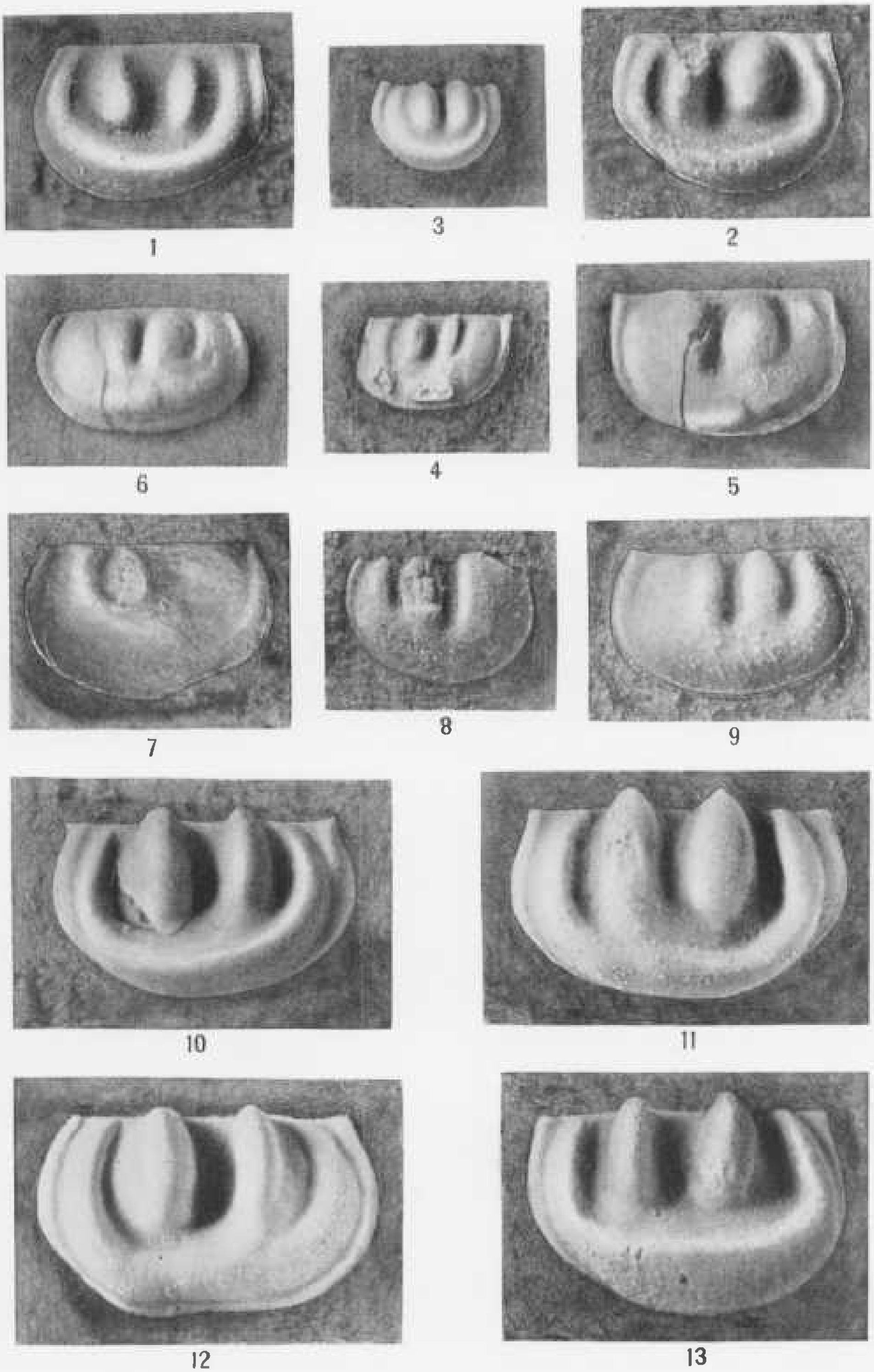
7. Right valve of female, × 12.
8. A shortened example, male, × 12.
9. Typical left valve, male, × 12, showing confluence of two anterior lobes.

Silurian, Mt. Wissick, Temiscouta Lake, Quebec.

FIGS. 10-13. DREPANELLINA CLARKI n. sp. 648

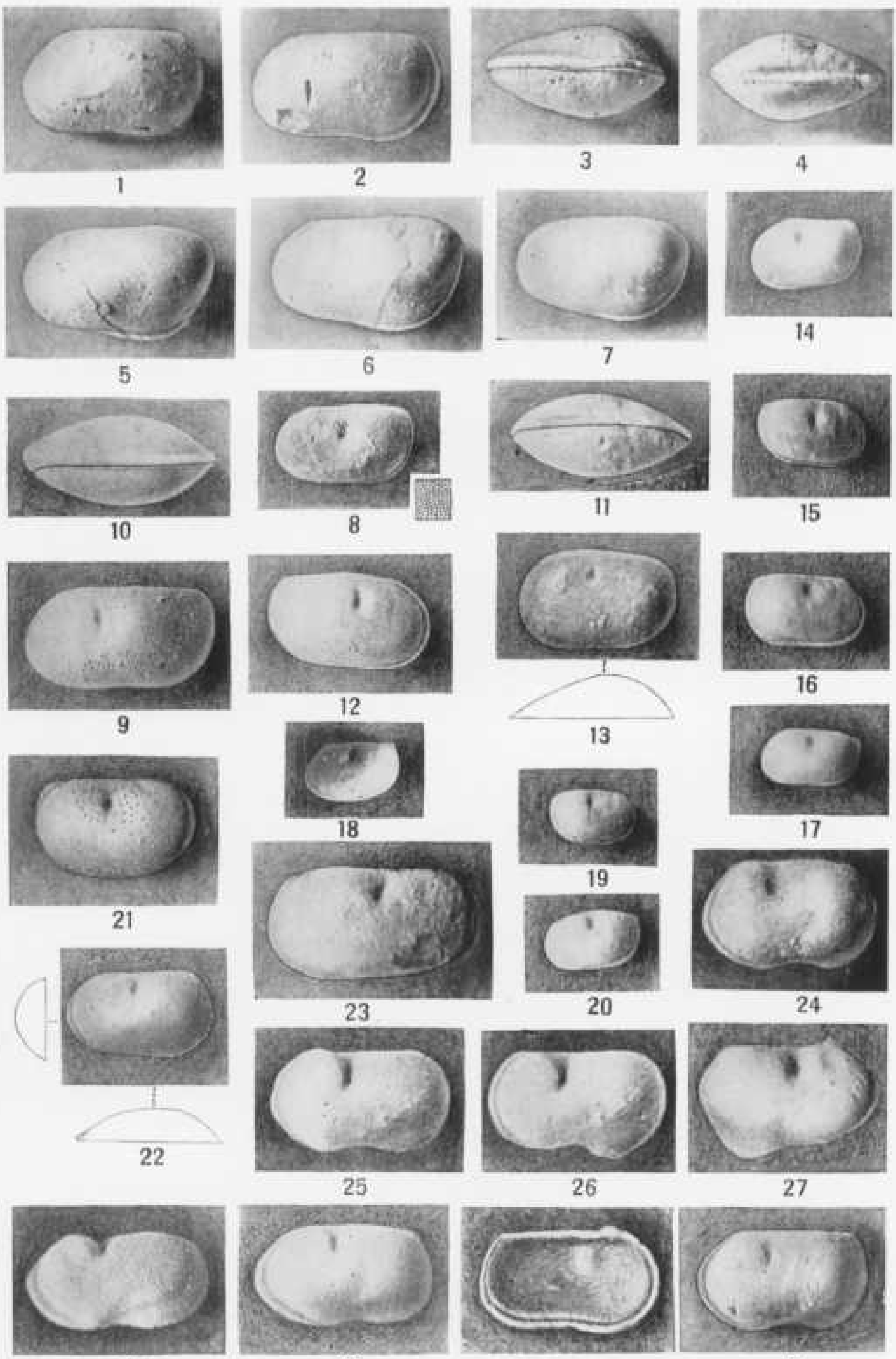
10. Slightly imperfect right valve, male, × 12.
11. Left valve, male, × 12.
12. Well preserved right valve, male, × 12.
13. Left valve, female, × 12.

Upper Clinton (*Drepanellina clarki* zone, 5 feet below top), Cumberland, Md.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LVII



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LVIII

PAGE

FIG. 1. EUKLOEDENELLA SINUATA ANGULATA n. var. 672
Left valve, × 20 (see also Pl. LVII, Figs. 28-31).
McKenzie formation (82 feet below top), Flintstone, Md.

FIGS. 2-5. EUKLOEDENELLA SINUATA PROCLIVIS n. var. 672
2. Right valve, × 20.
3, 4. Two left valves, × 20, different in size but similar otherwise.
5. Interior of right valve, × 20.
McKenzie formation (lower part), Cumberland, Md.

FIG. 6. EUKLOEDENELLA DORSATA n. sp. 673
Right valve, × 16, illustrating shallow umbilical depression.
McKenzie formation (82 feet below top), Flintstone, Md.

FIGS. 7-9. EUKLOEDENELLA PUNCTILLOSA n. sp. 673
7, 8. Two right valves, × 20, showing identity of characters, and a view of the punctate surface, × 50.
McKenzie formation (25 feet below top), Cumberland, Md.
9. A left valve, × 20, possibly representing a variety.
Wills Creek formation (45 feet above base), Pinto, Md.

FIGS. 10-12. EUKLOEDENELLA SULCIFRONS n. sp. 673
10. The type specimen, a left valve, × 16, with ventral and lateral edge views.
11. Right valve, × 16.
12. A left valve, × 20, referred with doubt to this species.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, Md.

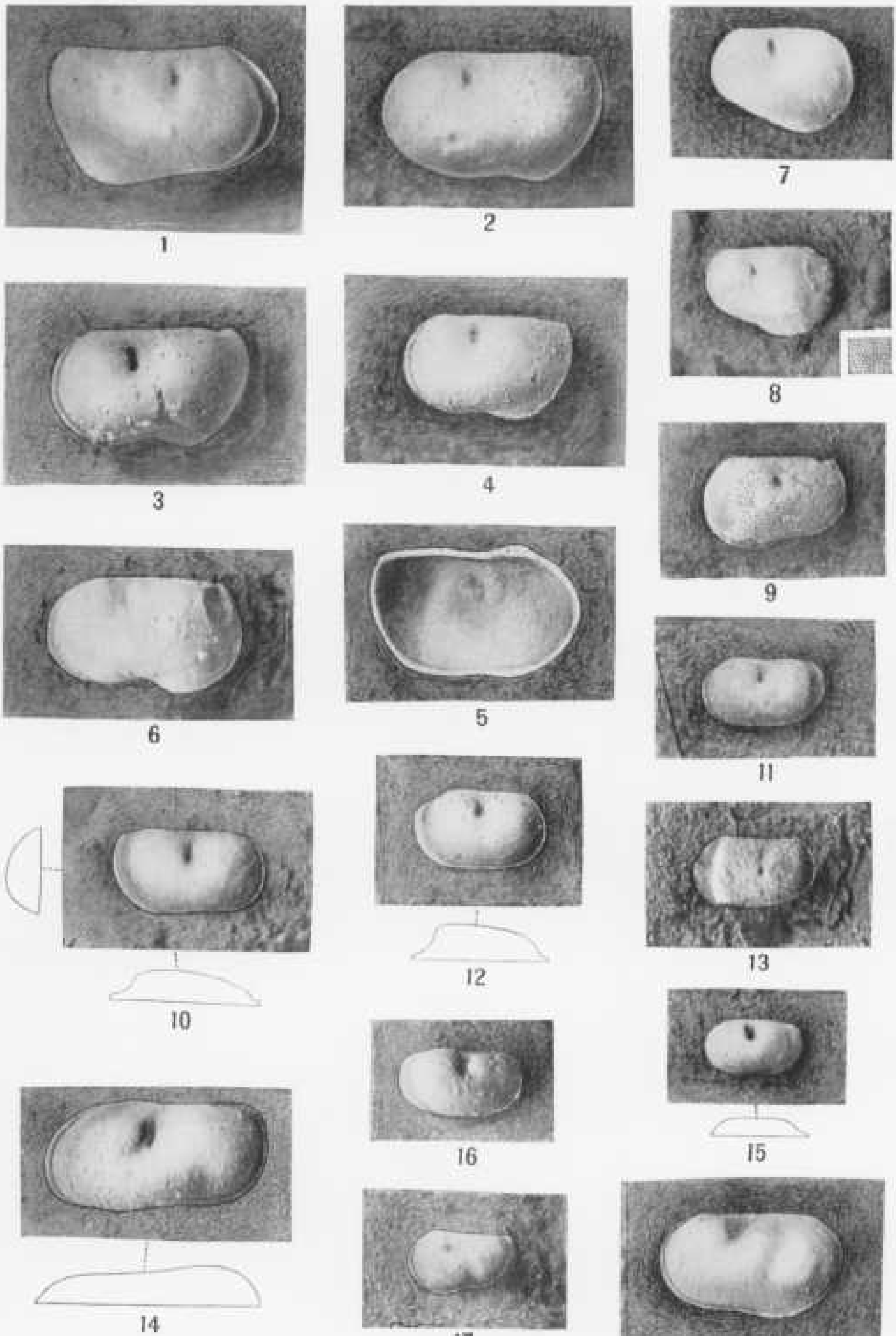
FIG. 13. EUKLOEDENELLA ABRUPTA n. sp. 674
A left valve, × 20, showing abrupt descent and flatness of crescentic border.
Upper Clinton (*Drepanellina clarki* zone), McKees Farm, 7 miles west of Lewiston, Pa.

FIG. 14. EUKLOEDENELLA LONGULA n. sp. 675
The type specimen, a right valve, × 20, and a ventral edge view of the same.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, Md.

FIGS. 15, 16. EUKLOEDENELLA SIMILIS n. sp. 674
15. Right valve, × 20, and ventral edge view.
16. Left valve, × 20, of a larger example.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, Md.

FIG. 17. EUKLOEDENELLA FOVEOLATA n. sp. 675
The type specimen, × 20.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, Md.

FIG. 18. EUKLOEDENELLA BULBOSA n. sp. 675
Right valve, × 16.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, Md.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LIX

PAGE

FIG. 1. KLOEDENELLA OBLIQUA n. sp. 676
A right valve, × 20, illustrating the oblique form.
Tonoloway formation (lower part), Cumberland, Md.

FIG. 2. KLOEDENELLA RECTANGULARIS n. sp. 676
Right valve, × 20, exhibiting the sharp rectangular anterior end.
Tonoloway formation (lower part), Cumberland, Md.

FIG. 3. KLOEDENELLA CACAPONENSIS n. sp. 677
Right valve, × 20, with obtusely angular anterior angle.
McKenzie formation (20 feet above base), 1½ miles east Great Cacapon, Md.

FIGS. 4-9. KLOEDENELLA SCAPHA n. sp. 677
4. Right side of carapace, × 20.
5, 6. Left side of two entire carapaces, × 20, illustrating constancy of characters.
7, 8. Right side of two examples, × 20.
McKenzie formation (30 feet above base), Flintstone, Md.
9. Right valve of a large carapace, × 20.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, Md.

FIG. 10. KLOEDENELLA SCAPHA BREVICULA n. var. 678
Right valve, × 20, of this short variety.
McKenzie formation (50-150 feet above base), Cumberland, Md.

FIGS. 11-13. KLOEDENELLA SUBOVATA n. sp. 679
Three right valves, × 20, exhibiting characters of the species.
McKenzie formation (82 feet below top), Flintstone, Md.

FIG. 14. KLOEDENELLA NITIDA n. sp. 679
Right side of carapace, × 20, exhibiting the short furrows and characteristic outline.
McKenzie formation (middle part), Cumberland, Md.

FIGS. 15, 16. KLOEDENELLA IMMERSA n. sp. 680
15. Right side of entire carapace, × 20, showing slight overlapping of left valve.
16. Left side of carapace, × 20.
McKenzie formation (middle part), Cumberland, Md.

FIGS. 17, 18. KLOEDENELLA GIBBEROSA n. sp. 680
17. Left valve, × 16, exhibiting the characteristic crestlike ridge on dorsal margin.
McKenzie formation (82 feet below top), Flintstone, Md.
18. Right valve, × 16, with ridge wanting but that on left valve visible.
McKenzie formation (100 feet below top), Pinto, Md.

FIGS. 19, 20. KLOEDENELLA TRANSITANS n. sp. 681
Right side of two entire carapaces, × 16, showing slight difference in length.
McKenzie formation (30 feet above base), Flintstone, Md.

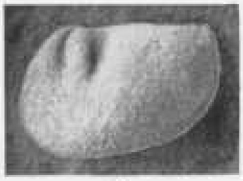
FIGS. 21-23. DIZYGOPLEURA PROUTYI n. sp. 682
21. Right valve, × 20.
22. Another right valve, × 20, showing practical identity with Fig. 21.
23. A small left valve, × 20.
Upper Clinton (*Drepanellina clarki* zone), Cumberland and Pinto, Md.

FIG. 24. DIZYGOPLEURA PRICEI n. sp. 682
Left valve, × 20, exhibiting the characteristic greater length than in *D. proutyi.*
Upper Clinton (*Drepanellina clarki* zone), Pinto, Md.

FIG. 25. DIZYGOPLEURA GIBBA n. sp. 684
Left side of entire carapace, × 20.
McKenzie formation (82 feet beneath top), Flintstone, Md.

FIG. 26. DIZYGOPLEURA MINIMA n. sp. 683
Right valve, × 20, of this minute but well characterized species.
Upper Clinton (*Mastigobolbina typus* zone), Hollidaysburg, Pa.

FIGS. 27-29. DIZYGOPLEURA LACUNOSA n. sp. 683
27, 28. Two left valves, × 20, illustrating the elongate carapace.
29. Right valve, × 20.
Upper Clinton (*Drepanellina clarki* zone), McKees Farm, 7 miles west of Lewiston, Pa., and 1½ miles east of Great Cacapon, Md.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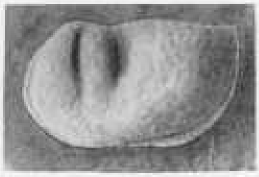
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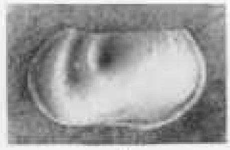
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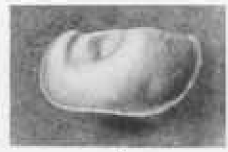
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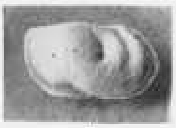
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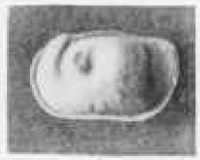
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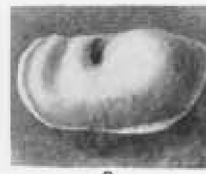
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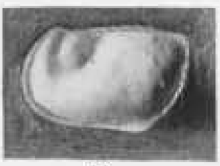
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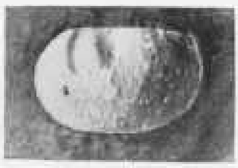
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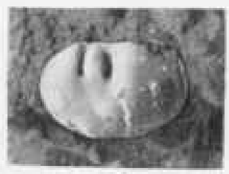
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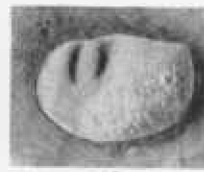
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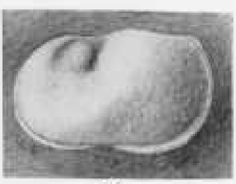
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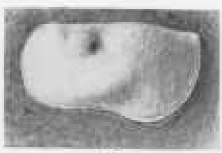
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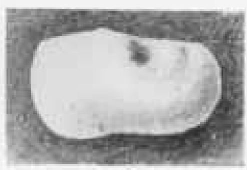
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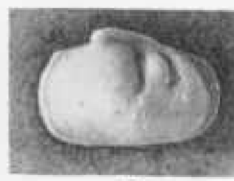
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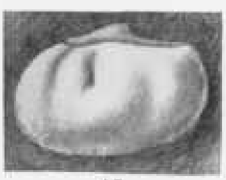
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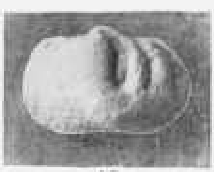
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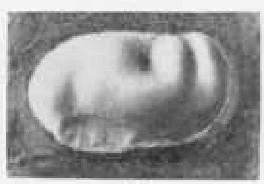
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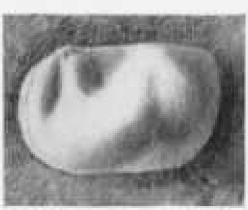
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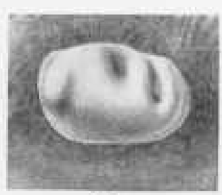
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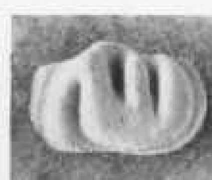
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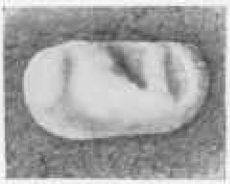
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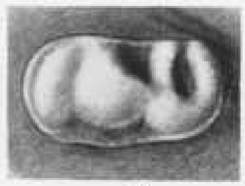
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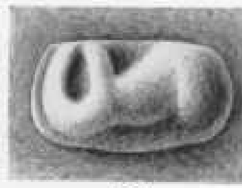
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ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LX

PAGE

FIGS. 1-3. DIZYGOPLEURA CARINATA n. sp. 684

1. Right valve, × 20, exhibiting the carination of the posterior and antero median lobes.
2. Ventral edge view of the same valve, × 20.
3. Interior of small right valve, × 20, probably of this species.

McKenzie formation (Upper), Cumberland, Md.

FIGS. 4-9. DIZYGOPLEURA ACUMINATA n. sp. 685

4. Ventral edge view, × 20, of entire carapace.
5. Left valve of a small variety, × 20, with anterior sulcus stronger than in typical form.
6. Typical left valve, × 20.

McKenzie formation (25 feet below top), Cumberland, Md.

7. Right valve, × 16, of typical form.
8. Right valve, × 16, doubtfully referred to the species, introduced to show derivation of *D. affinis*.
9. Right valve, × 16.

McKenzie formation (24 feet below top), Flintstone, Md.

FIGS. 10-12. DIZYGOPLEURA ACUMINATA PROLAPSA n. var. 685

10. Right valve, × 12, exhibiting the strong inflation of the ventral part of anterior lobe.
11. Left valve, × 12.
12. Ventral edge view of entire carapace, × 12.

McKenzie formation (24 feet below top), Flintstone, Md.

FIG. 13. DIZYGOPLEURA AFFINIS n. sp. 686

Right side, × 20, of the type specimen, a complete carapace.

Wills Creek formation (90 feet below top), Grasshopper Run, near Hancock, Md.

FIG. 14. DIZYGOPLEURA BULBIFRONS n. sp. 687

The type specimen, a right valve, × 16.

McKenzie formation (77 feet below top), Flintstone, Md.

FIGS. 15, 16. DIZYGOPLEURA INTERMEDIA n. sp. 688

Right and left valve, × 20.

McKenzie formation (lower part), Cumberland, Md.

FIG. 17. DIZYGOPLEURA INTERMEDIA CORNUTA n. var. 688

An imperfect right valve, ×16, exhibiting the blunt spine near the middle of the cardinal edge.

Upper Clinton (basal part *Drepanellina clarki* zone), 1½ miles east of Great Cacapon, Md.

FIGS. 18-20. DIZYGOPLEURA INTERMEDIA ANTECEDENS n. var. 688

The type specimen, a right valve, × 16, with ventral and lateral edge views of the same.

Upper Clinton (basal part *Drepanellina clarki* zone), 1½ miles east of Great Cacapon, Md.

FIG. 21. DIZYGOPLEURA PLANATA n. sp. 689

A right valve of this species, × 20, introduced for comparison with *D. intermedia*.

Manlius limestone, Herkimer Co., N. Y.

FIG. 22. DIZYGOPLEURA HIEROGLYPHICA (Krause) 699

A right valve, × 20, introduced for comparison with American species of this group.

Silurian drift of Germany.

FIGS. 23, 24. DIZYGOPLEURA COSTATA n. sp. 700

Two right valves, × 20, showing the grooved summits of the ridges and other specific characters.

Tonoloway formation (upper part), Keyser, W. Va.

FIG. 25. DIZYGOPLEURA UNIPUNCTATA n. sp. 699

Right valve, × 20, exhibiting the characteristic single pit in the ventral part.

McKenzie formation (77 feet below top), Flintstone, Md.

FIG. 26. DIZYGOPLEURA PERRUGOSA n. sp. 700

A typical left valve, × 20.

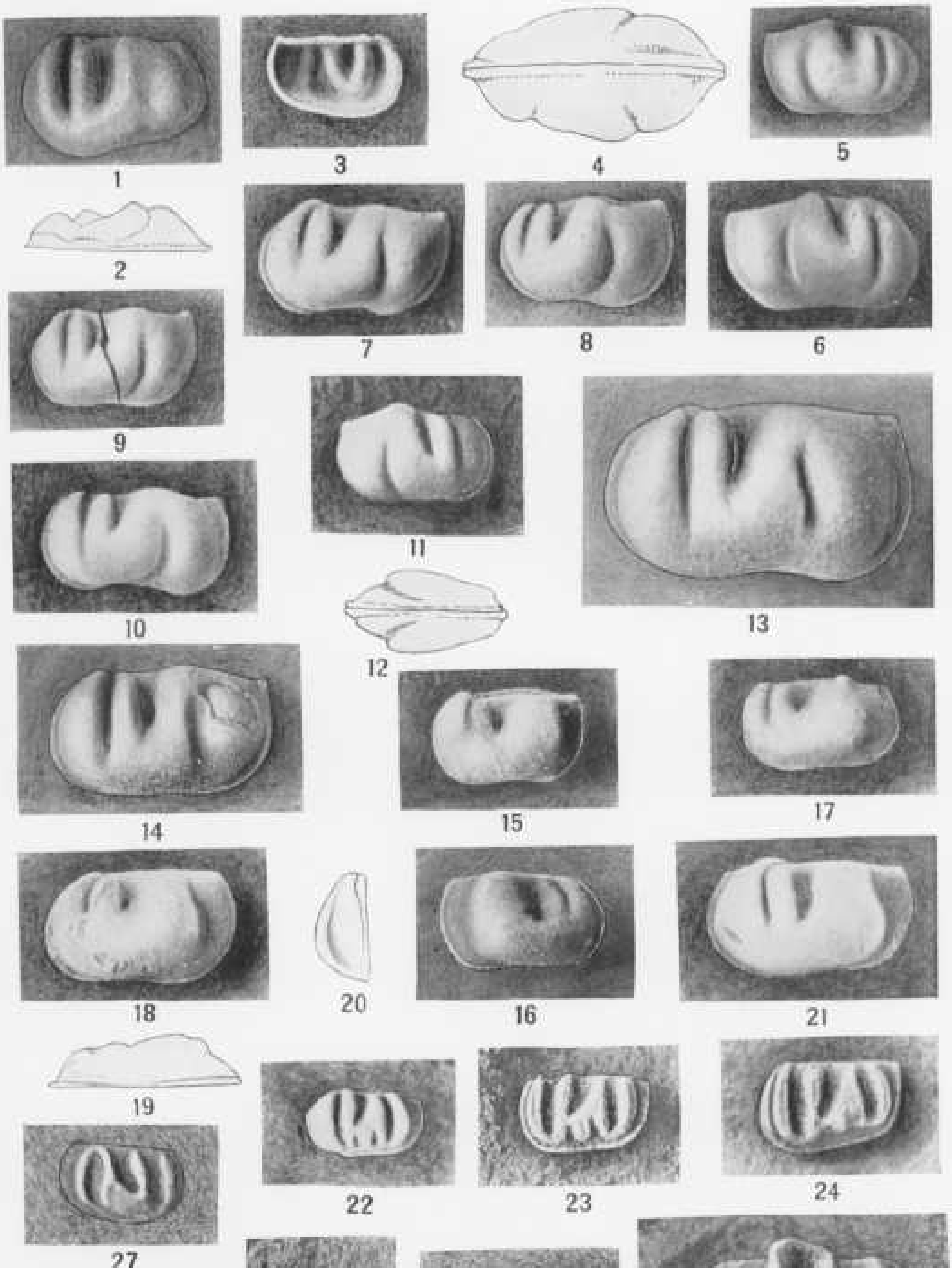
McKenzie formation (middle part), Cumberland, Md.

FIGS. 27-29. DIZYGOPLEURA VIRGINICA n. sp. 699

27, 28. Two right valves, × 20, exhibiting the thin ridges and the lack of the two pits in the ventral thickening of the loop.

29. A slightly shortened left valve, × 20.

Base of Sneedville limestone (McKenzie formation), Big Stone Gap, Va.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LXI

PAGE

FIGS. 1, 2. DIZYGOPLEURA SUBDIVISA n. sp. 689
The type specimen, a right valve, × 20, of this minute species.
McKenzie formation (30 feet above base), Flintstone, Md.
2. Right valve, × 20, of variety in which the lobation of *Dizygopleura* is developed.
McKenzie formation, Cumberland, Md.

FIG. 3. DIZYGOPLEURA MICULA n. sp. 690
Right valve, × 20.
McKenzie formation (30 feet above base), Flintstone, Md.

FIGS. 4-8. DIZYGOPLEURA CRANEI n. sp. 690
4. Cast of left valve, × 20.
5. Similar cast of right valve, × 20.
6, 7. Two smaller right valves, × 20, showing slight variations.
8. A larger right valve, × 20.
Upper Clinton (*Drepanellina clarki* zone), McKees Farm, 7 miles west of Lewiston, Pa.

FIGS. 9, 10. DIZYGOPLEURA ASYMMETRICA n. sp. 690
9. Right valve, × 16, with wide anterior flange.
10. Left valve, × 20, showing it to be less elongated than the right.
Upper Clinton (*Drepanellina clarki* zone), Cumberland, Md.

FIG. 11. DIZYGOPLEURA CONCENTRICA n. sp. 691
The type specimen, a right valve, × 20.
McKenzie formation (100 feet beneath top), Pinto, Md.

FIG. 12. DIZYGOPLEURA CONCENTRICA SUBQUADRATA n. var. 692
Right valve, × 20, of this minute early variety.
McKenzie formation (30 feet above base), Flintstone, Md.

FIGS. 13, 14. DIZYGOPLEURA LOCULATA n. sp. 691
Two right valves, × 20, illustrating slight differences.
Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.

FIGS. 15-19. KLOEDENIA NORMALIS n. sp. 639
15, 16. Two right valves, × 20, with brood pouch developed.
17, 18. Left and right valves of male, × 12.
McKenzie formation (182 feet beneath top), Pinto, Md.
19. Right valve of female, × 12, of Wills Creek variety.
Wills Creek formation (45 feet above base), Pinto, Md.

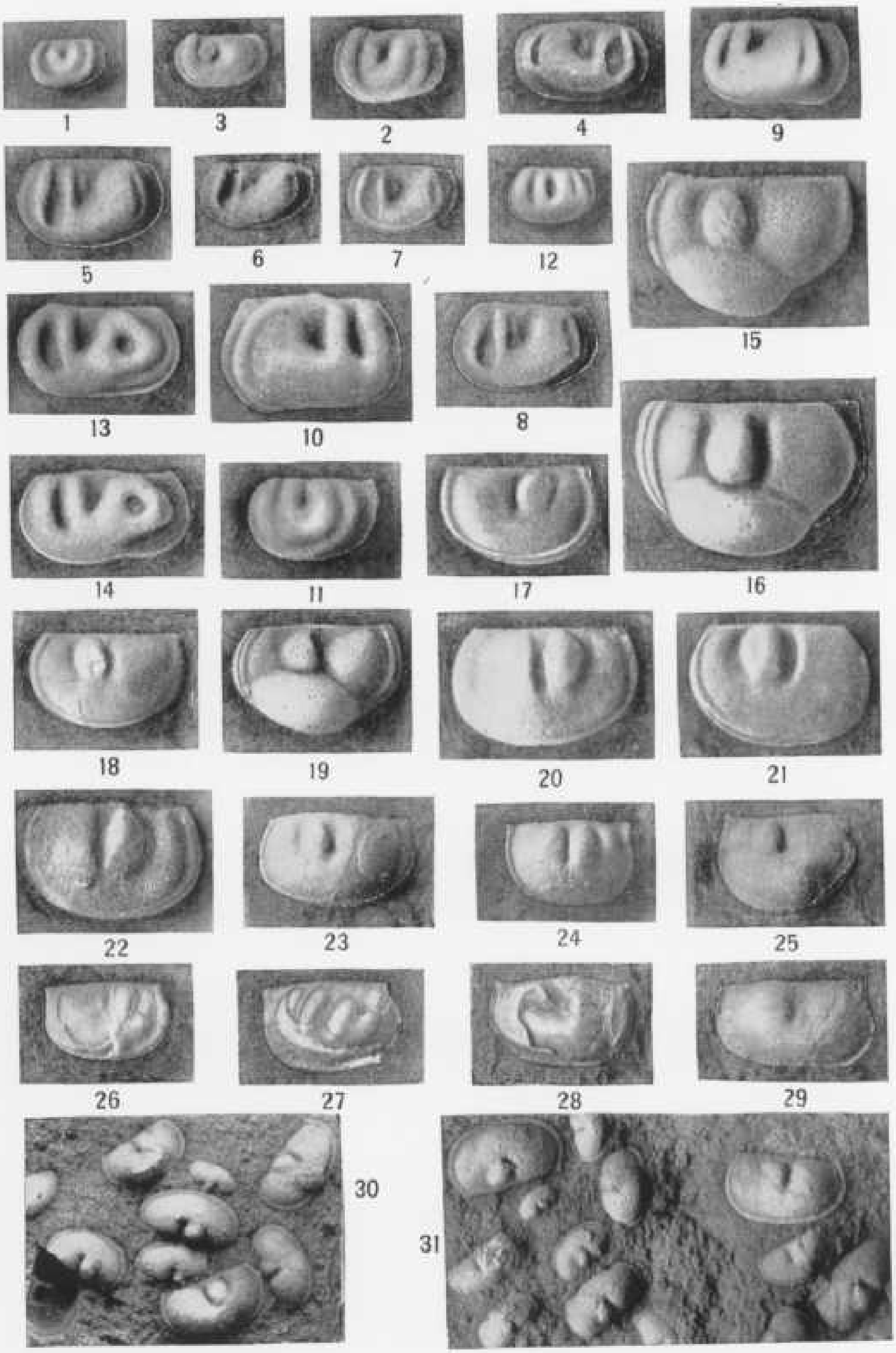
FIGS. 20-22. KLOEDENIA NORMALIS APPRESSA n. var. 639
20, 21. Left and right valves of male, × 20, illustrating the shorter form and less regularly rounded outline.
22. Another male left valve, × 20.
Wills Creek formation (162 and 182 feet above base), Flintstone, Md.

FIG. 23. KLOEDENIA KENZIENSIS n. sp. 640
The type specimen, a male right valve, × 20.
McKenzie formation (100 feet beneath top), Pinto, Md.

FIGS. 24, 25. KLOEDENIA CACAPONENSIS n. sp. 640
24. Young specimen, male left valve, × 12.
25. Right valve, female, × 12.
Top of Upper Clinton, 1½ miles east of Great Cacapon, W. Va.

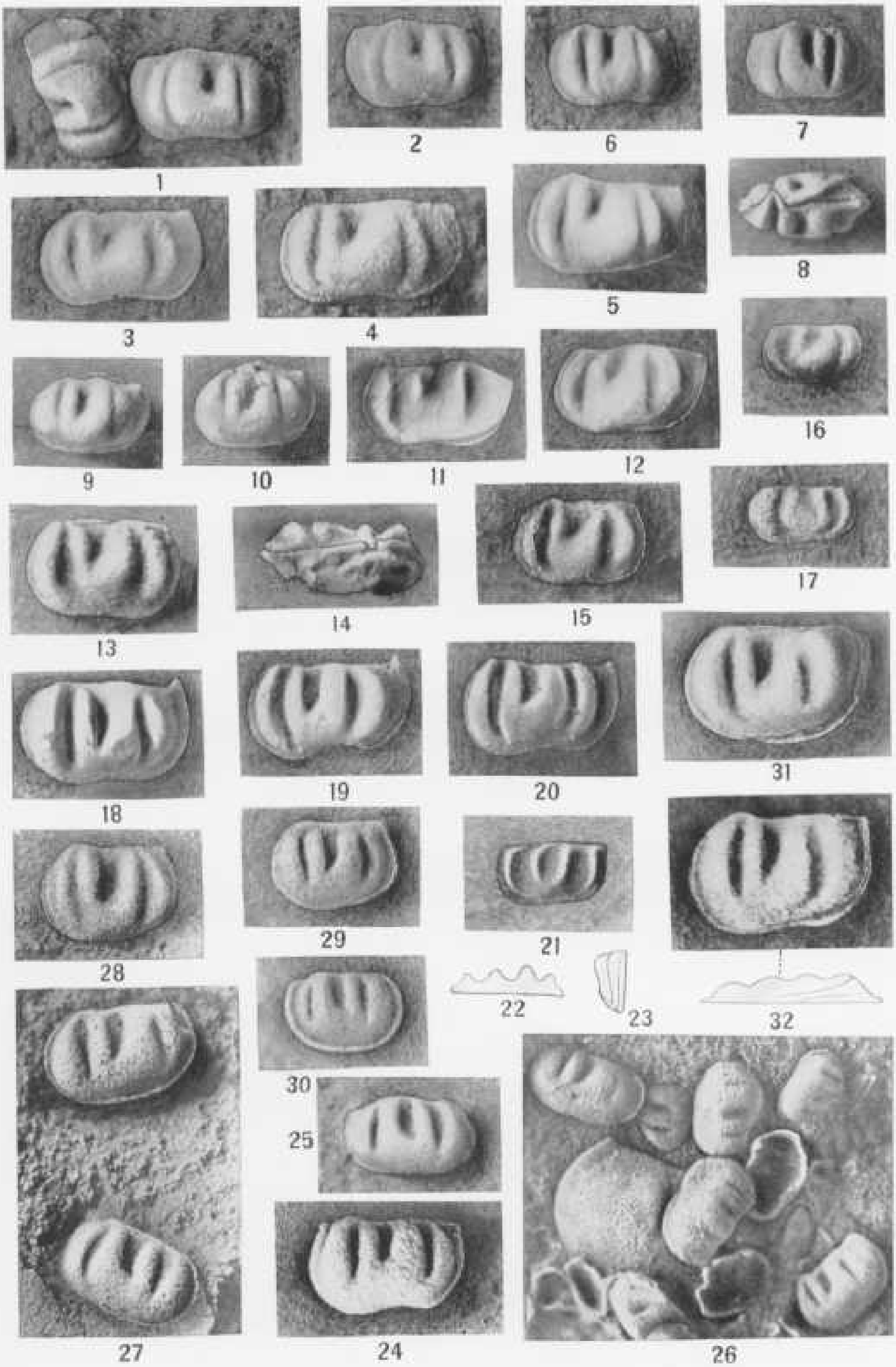
FIGS. 26-29. KLOEDENIA OBSCURA n. sp. 641
26. The holotype, × 8, a specimen retaining most of the pseudomorph of the shell.
27. Right valve of male, × 8.
28. Left valve, × 8. Partial cast of interior showing mold of insloping edge.
29. Cast of interior, × 8, right valve, male.
Top of Lower Clinton, 8 feet above Frankstown ore bed, ½ mile northwest of Frankstown, Pa.

FIGS. 30, 31. KLOEDENIA LONGULA n. sp. 640
Two surfaces of a slab, × 12, showing great abundance of this elongate species.
Wills Creek formation (lower part), Flintstone, Md.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LXII



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LXIII

PAGE

FIGS. 1, 2. BYTHOCYPRIS (?) KEYSERENSIS n. sp. 703
Two valves, × 20, illustrating outline and general characters.
Tonoloway formation (upper part), Keyser, W. Va.

FIGS. 3, 4. BYTHOCYPRIS PERGRACILIS n. sp. 703
Two valves, × 20, of this slender species.
McKenzie formation (20 feet above base), 1½ miles east of Great Cacapon, W. Va.

FIGS. 5, 6. BYTHOCYPRIS PHASEOLUS Jones 702
Opposite valves, × 20.
Tonoloway formation (upper part), Keyser, W. Va.

FIG. 7. BYTHOCYPRIS PHASEOLINA n. sp. 703
The type specimen, × 20.
Tonoloway formation (lower part), Keyser, W. Va.

FIG. 8. BYTHOCYPRIS OBESA Jones 702
The Maryland specimen, × 20, referred to this species.
McKenzie formation, Cumberland, Md.

FIG. 9. BYTHOCYPRIS PHILLIPSIANA Jones and Hall 702
Valve, × 20.
McKenzie formation (82 feet below top), Flintstone, Md.

FIGS. 10, 11. OCTONARIA MURICATA n. sp. 701
10. Small valve, × 20, illustrating the surface ornamentation.
11. A larger valve, × 20, in which the pit is quite distinct.
Tonoloway formation (upper part), Keyser, W. Va.

FIG. 12. OCTONARIA CRANEI n. sp. 701
Right valve, × 20, illustrating the oblong form and shape of the ridge.
Upper Clinton (*Drepanellina clarki* zone), McKees Farm, 7 miles west of Lewiston, Pa.

FIGS. 13-15. DIBOLBINA CRISTATA n. sp. 659
13. Right valve, male, × 20.
14. Left valve, male, × 20.
15. Right valve, female, × 20, with the frill restored in outline.
Tonoloway formation (upper part), Keyser, W. Va.

FIG. 16. DIBOLBINA PRODUCTA n. sp. 660
The type specimen, a left valve, male, × 20.
Tonoloway formation (128 feet above base), Grasshopper Run, near Hancock, Md.

FIGS. 17-20. BEYRICHIA MESLERI n. sp. 653
17, 18. Two right valves, × 16, showing similarity to *B. moodeyi* but lacking surface punctation.
19, 20. Left valve, × 16.
McKenzie formation (82 feet below top), Flintstone, Md.

FIGS. 21-24. BEYRICHIA VERONICA n. sp. 654
21. A testiferous right valve, male, × 20, with surface punctation well preserved.
22. A left valve, male, × 20, showing convexity. The frill as usual is imperfectly preserved.
23. Cast of interior left valve, × 20, with ventral border broken away.
Upper Clinton (*Drepanellina clarki* zone, 17 inches above Keefer sandstone), 1½ miles east Great Cacapon, Md.
24. Right valve, female, × 12.
Upper Clinton (*Mastigobolbina typus* zone), Cumberland, Md.

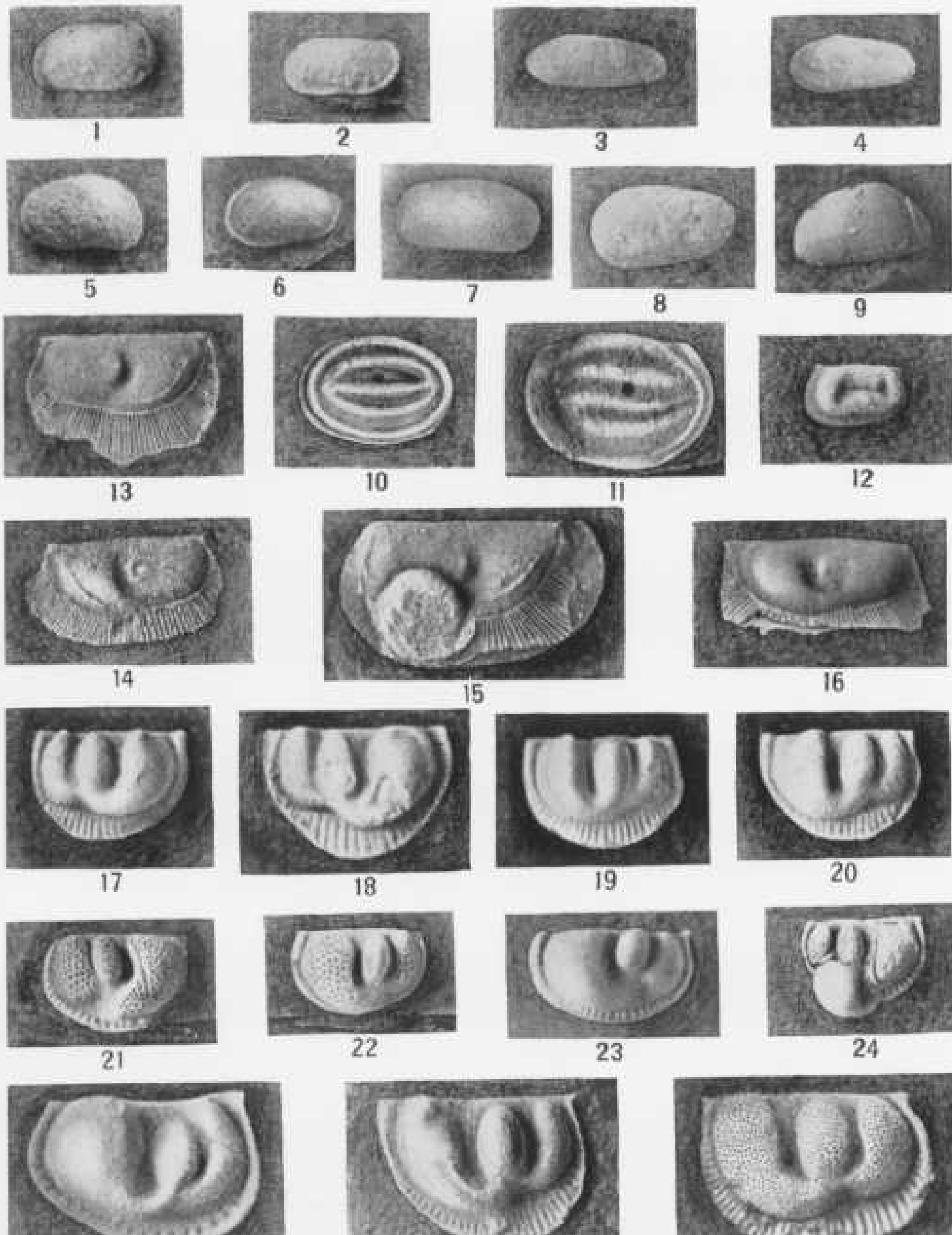
FIG. 25. BEYRICHIA LAKEMONTENSIS n. sp. 652
Male left valve, × 16, showing resemblances to *B. kirki* but having frill radially marked by widely spaced striations.
Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.

FIG. 26. BEYRICHIA TONOLOWAYENSIS n. sp. 654
The type specimen, a left valve, × 20.
Tonoloway formation (128 feet above base), Grasshopper Run, near Hancock, Md.

FIG. 27. BEYRICHIA MOODEYI Ulrich and Bassler 655
One of the original types, × 20, exhibiting the surface reticulation distinctly.
McKenzie formation (lower part), 1½ miles east Great Cacapon, W. Va.

FIG. 28. BEYRICHIA EMACIATA n. sp. 651
The imperfectly preserved specimen, a right valve, × 20, upon which the species is founded.
Lower Clinton (57 feet above base), Wills Creek Gorge, Cumberland, Md.

FIGS. 29, 30. BEYRICHIA KIRKI n. sp. 652
29. Complete male right valve, × 16, exhibiting long hinge, narrow anterior end and thickened rim of border without striation.
30. Female right valve, × 16.
Upper Clinton (*Mastigobolbina typus* zone), Lakemont, Pa.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LXIV

All figures on this plate, × 8.

PAGE

FIGS. 1, 2. ZYGOBOLBA CURTA n. sp. (see also Pl. LXV, Fig. 27) 557
Two right valves of males, from the Lower Clinton at Hagans, Va., showing the short and truncated subcircular outline, rather flat border, and relatively thin lobes that characterize the species.

FIGS. 3-7. ZYGOBOLBA ANTICOSTIENSIS n. sp. 557
3 and 4. Two left male valves, the first uncommonly short, the second a typical example but tilted slightly in posing so that the height appears a little less than it should.
5. A small right valve.
6. A large but imperfect male right valve.
Gun River formation, Anticosti.
7. Cast of the interior of a right valve, preserved in shale.
Lower Clinton, Hagans, Va.

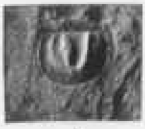
FIGS. 8-13. ZYGOBOLBA EXCAVATA n. sp. (see also Pl. LXV, Fig. 6) 557
8 and 9. Right and left valves of males, the cotypes of the species, showing the extraordinarily wide and deeply excavated border and the general steepness and eveness of the anterior slope.
Gun River formation, Anticosti.
10. Cast of the interior of a left valve in shale, preserving an impression of a part of the wide outer border. The latter usually breaks away in splitting the shale.
Lower Clinton, Hagans, Va.
11. A similar cast lacking all but the base of the outer border.
Williamson shale, Rochester, N. Y.
12 and 13. Casts of the interior of right and left valves in similar preservation.
Lower Clinton *Zygobolba anticostiensis* and *Anoplotheca hemispherica* (? Sowerby) Hall zone at Hagans, Va.

FIGS. 14-17. ZYGOBOLBA PROLIXA n. sp. 558
14. Right valve, male, cast of interior in shale. Only the base of the nearly erect thin outer border is retained.
15. Mold of the exterior of a left valve giving some idea of the upturned outer border.
16. Another interior cast of a right valve.
17. Left valve of female showing rather small size of the brood pouch, the species approaching *Z. oblonga* in this respect.
Lower Clinton, *Z. anticostiensis* zone, Hagans, Va.

FIGS. 18 and 19. ZYGOBOLBA ROBUSTA n. sp. 558
Two left valves, males, indicating the large size attained by the species and its general characters.
Jupiter River formation, Anticosti.

FIG. 20. ZYGOBOLBA INTERMEDIA n. sp. 559
Right valve, male, the holotype. The species is allied on the one hand to *Z. robusta* and on the other to *Z. excavata*, but differs from both in its outline and in details of lobation.
Jupiter River formation, Anticosti.

FIGS. 21-25. ZYGOBOLBA DECORA (Billings) (see also Pls. XXXIX and XL). 537
21 and 22. Right and left valves of the male.
23. Inner side of a right valve, the anterior dorsal angle a trifle sharper than usual.
24. Four valves, the two in upper half of figure being right and left valves of males (*Beyrichia venusta* Billings), the two in the lower half right valves of females (*Beyrichia decora* Billings).
25. Two other valves of male form, the upper a left, the lower a right.
Jupiter River formation, Anticosti.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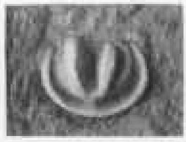
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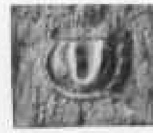
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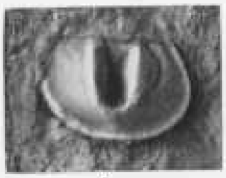
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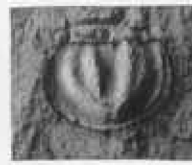
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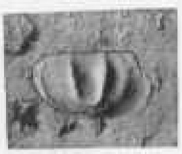
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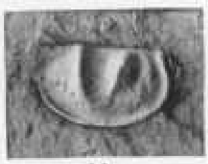
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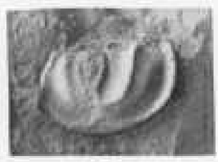
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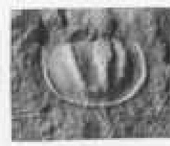
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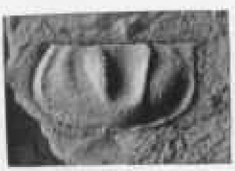
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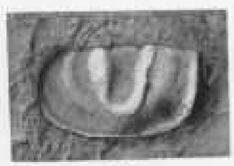
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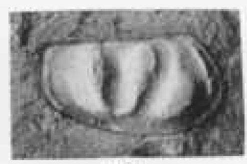
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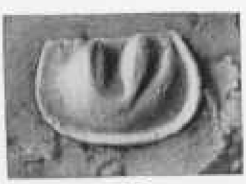
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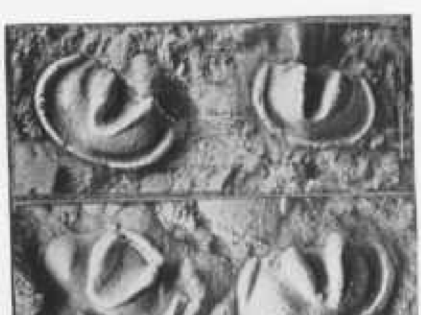
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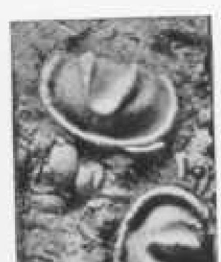
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ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LXV

All figures on this plate, × 8.

PAGE

FIGS. 1-4. ZYGOBOLBA RECTANGULA n. sp. 560

1, 2. Left valves showing the general characters of the species and particularly, when compared with *Z. twenhofeli*, the lesser fullness of the ventral part of the posterior lobe, thicker median lobe, longer and dorsally less diverging limbs of the U-shaped loop and the inferior convexity of the outer two-thirds of the anterior lobe.

3. A large right valve, tilted in posing so that the anterior edge lies below the normal plane of the valve, causing the anterior lobe to appear too narrow and the posterior lobe correspondingly too wide.

4. Smaller right valve, imperfect at antero-dorsal angle.

Gun River formation, Anticosti.

FIGS. 5-9. ZYGOBOLBA TWENHOFELI n. sp. 560

5. Left valve of typical form, possibly female, in which case the original of Fig. 7 would represent the male of the typical variety.

6. Right valve of female, doubtfully referred to this species, but possibly belonging to *Z. rectangula*.

7. Right valve approaching *Z. excavata* in the ventral reduction of the posterior lobe.

8, 9. Two left valves of a variety with ventral parts of anterior and posterior lobes full as in the typical form of the species but resembling *Z. rectangula* in the form of the antero-cardinal angle and the strong inflation of the median lobe.

Gun River formation, Anticosti.

FIGS. 10, 11. ZYGOBOLBA OBLONGA n. sp. 560

10. Right valve, male.

11. Left valve, female, showing relatively very small brood pouch which is characteristic of this species.

Lower Clinton, Hagans, Va.

FIGS. 12-26. ZYGOBOLBA INFLATA n. sp. 562

12. Left valve, male, of the short variety.

13. Right valve, female, of the short variety.

14. Right valve, male, also of the short variety.

15. Left valve, male, young, evidently of the var. *recurva*.

16, 17. Two right valves, young, of the var. *recurva*.

18. A broken left valve, probably of same variety.

Gun River formation, Anticosti.

19, 20. Two left valves, male, in shale, of the typical form of species.

21. Right valve, female, somewhat crushed, of the variety *recurva*.

Lower Clinton, Hagans, Va.

22. Left valve, male, type of the species. Closely allied to *Z. rectangula* but differs in the characters of its lobes and relatively greater height of its posterior half.

Gun River formation, Anticosti.

23, 24. Two right valves differing in proportions of length and height, the former a little shorter, the latter slightly longer than the typical form. These specimens, like those from Hagans, Va., are preserved in shale as casts of the interior, in which the lobes appear narrower than in the testiferous examples from Anticosti.

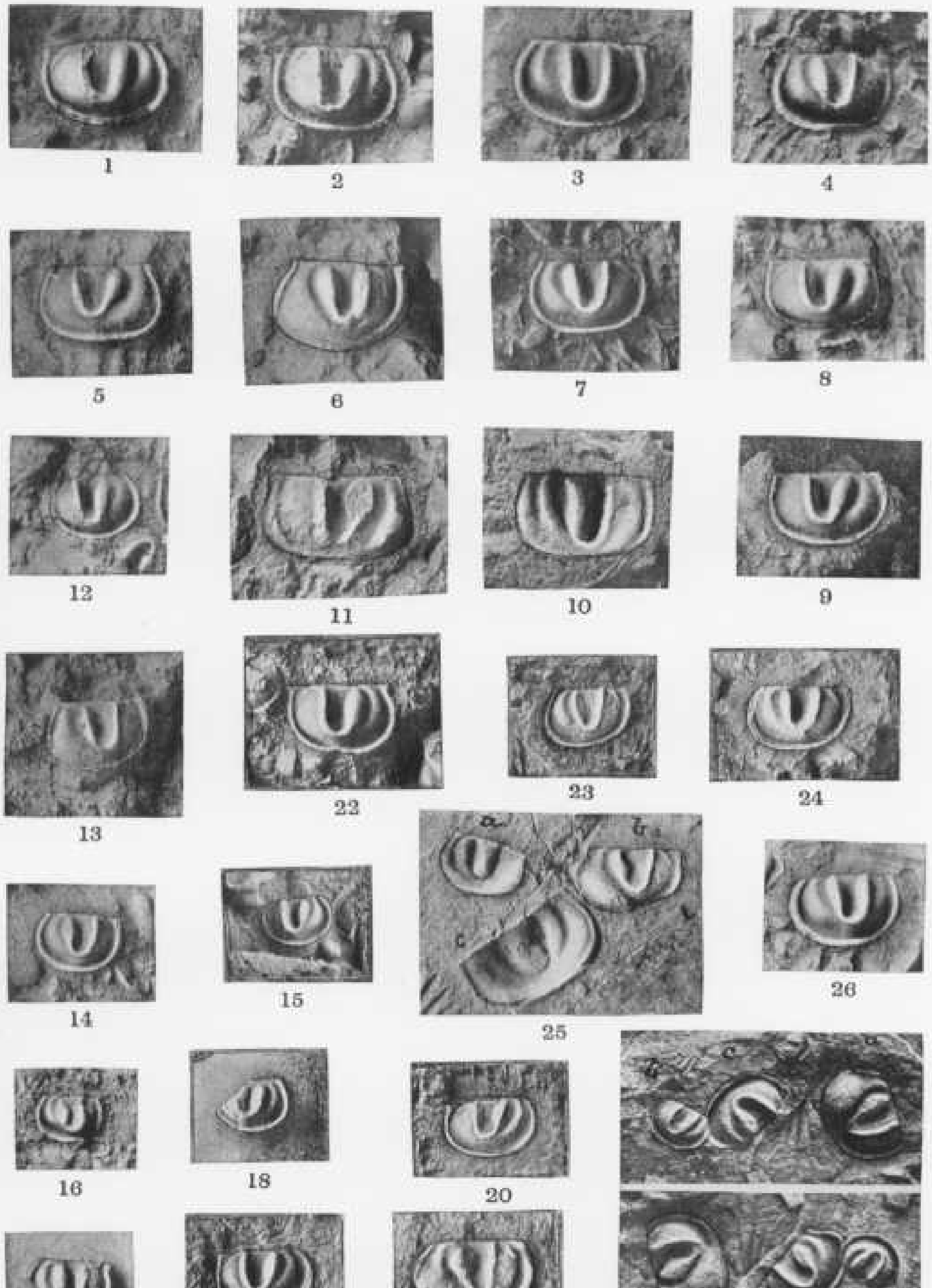
Williamson shale, Rochester, N. Y.

25. Part of the surface of a piece of shale from the Middle Clinton at Hagans, Va. *a* represents a poorly lighted exterior mold of a left valve, *b* an interior cast of a right female valve, both of this species, and *c* the mold of the exterior of a right valve of *Z. prolixa* (see Pl. LXIV, Figs. 14-17).

26. A left valve, male, the largest of the var. *recurva* observed in the collections from the Gun River formation of Anticosti. We may call it the holotype of the variety.

FIG. 27, *a*, *b*, *c*. ZYGOBOLBA CURTA n. sp. and Z. INFLATA var. 557

The two halves of this figure show the same three valves in different lighting. *a* represents a right female valve and *b* a much smaller left male valve of *Z. curta* (see also Pl. LXIV, Figs. 1, 2) and *c* a left valve, male, of a longish variety of *Z. inflata* like that from Rochester, N. Y., shown in Fig. 24. These were photographed as they lie on the surface of a thin piece of shale from the Lower Clinton at Hagans, Va.



ARTHROPODA-CRUSTACEA-OSTRACODA.

PLATE LXVI

PAGE

FIG. 1. EURYPTERUS FLINTSTONENSIS Swartz 716

Exfoliated carapace.

Tonoloway formation, Small Quarry on National Road on Martin Mt., Md.

FIG. 2. cf. HUGHMILLERIA SHAWANGUNK Clarke and Ruedemann 716

Carapace.

Wills Creek formation, Cement works, Wills Creek, Cumberland, Md.

FIGS. 3, 4. DOLICHOPTERUS CUMBERLANDICUS Swartz 717

3. Carapace.

4. Abdominal view of type.

Wills Creek formation, Riverside, W. Va.

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ARTHROPODA-MEROSTOMATA.

PLATE LXVII

1. Dorsal view of small specimen.

    Wills Creek formation, Cedar Cliff, W. Va.

2. Portion of abdomen showing segments.
3. Swimming and walking legs and fragments of body.

    Wills Creek formation, Riverside, W. Va.

4. Fragment of a carapace.
5. Distorted carapace of a *Dolichopterus* or a *Pterygotus*.
6. Telson of a *Pterygotus*.

    McKenzie formation (Keefer sandstone), near Lock 53, 3 to 4 miles west of Hancock, Md.

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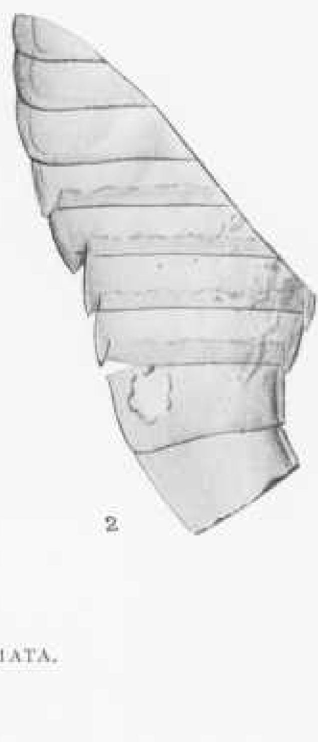

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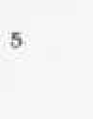

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ARTHROPODA-MEROSTOMATA.

GENERAL INDEX

PALEONTOLOGICAL INDEX

Figures in **bold face** indicate principal discussion

A

B

C